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Monthly Bulletin of the International Railway Congress Association

(English Edition)

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Alphabetical Index of Advertisers

Firms :		Specialities :
A E I (Associated Electrical Industries Limited)	V	Traction problems.
Alsthom	—	Electric locomotives.
Belgian Railways	—	Trans Europ Express.
Beyer Peacock (Hymek) Ltd.	VII	Diesel-hydraulic locomotives.
B.P.	X	Railway lubrication.
Cockerill-Ougrée (S.A.)	IX	Steam and Diesel locomotives.
Electromécanique (S.A.)	IV	Butt welding of rails.
English Electric Company Ltd. (The)	—	Railway electrification.
Ericssons (LM) Signalaktiebolag.	—	Railway signalling.
Ganz-Mávag	—	Locomotives and railway carriages.
General Electric Co. Ltd. (The)	—	Electric traction equipment.
Glaceries de la Sambre (S.A.)	—	Polished plate glass.
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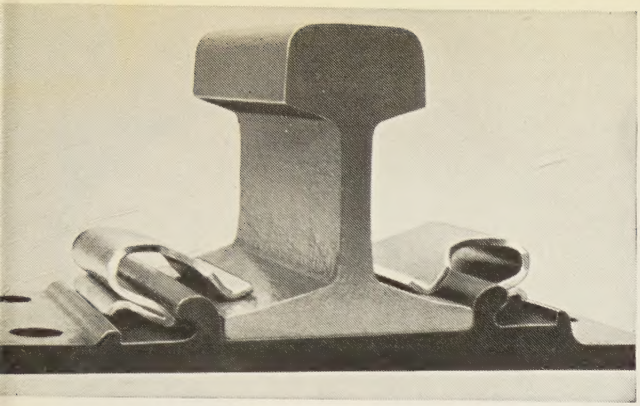
Westinghouse Brake and Signal Co., Ltd.	I	Railway signalling. Brakes.
Workington Iron & Steel Co.	III	Rails, fish plates, sole plates.



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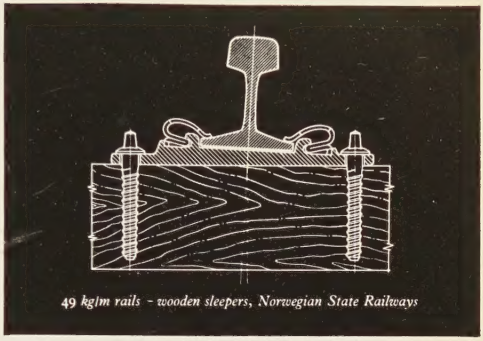
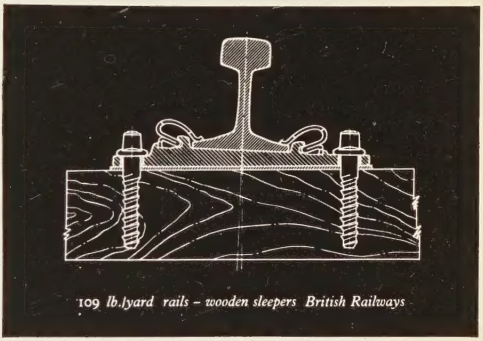


49 kg/m rails - wooden sleepers, Norwegian State Railways



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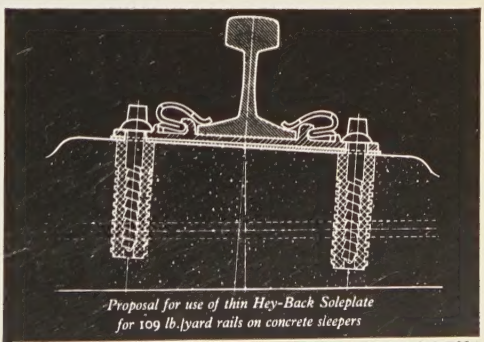
49 kg/m rails – concrete sleepers, Norwegian State Railways



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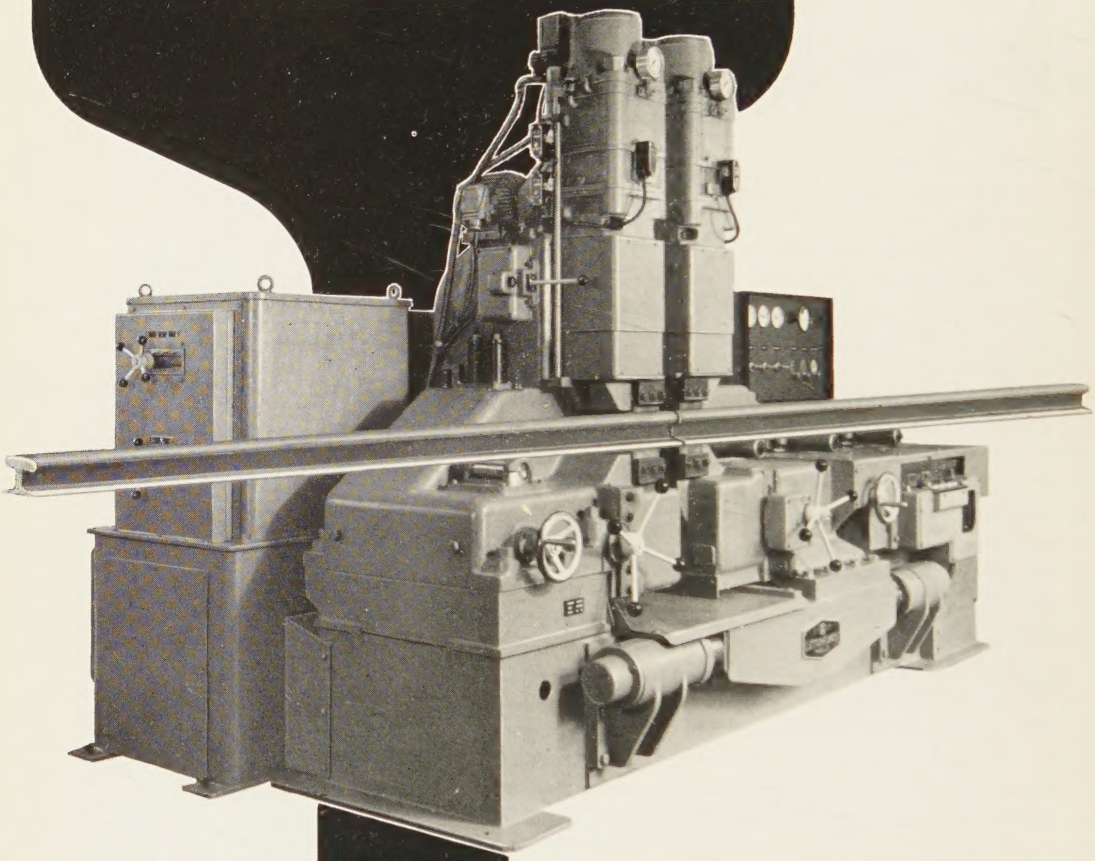

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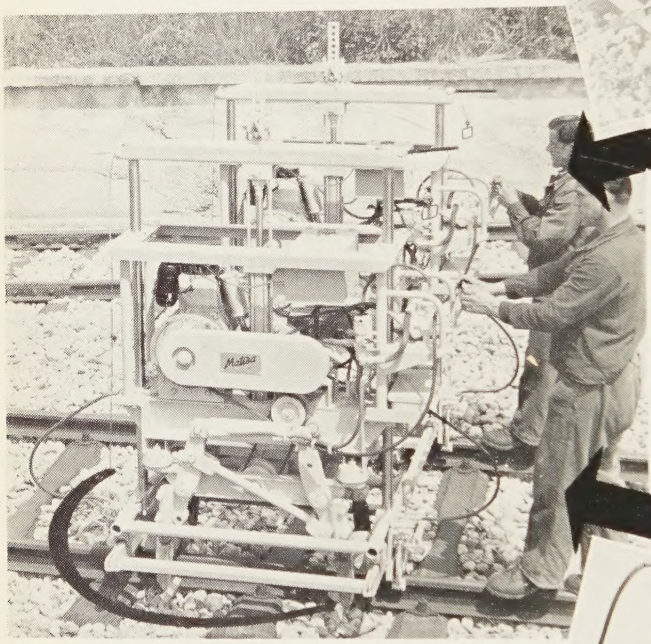

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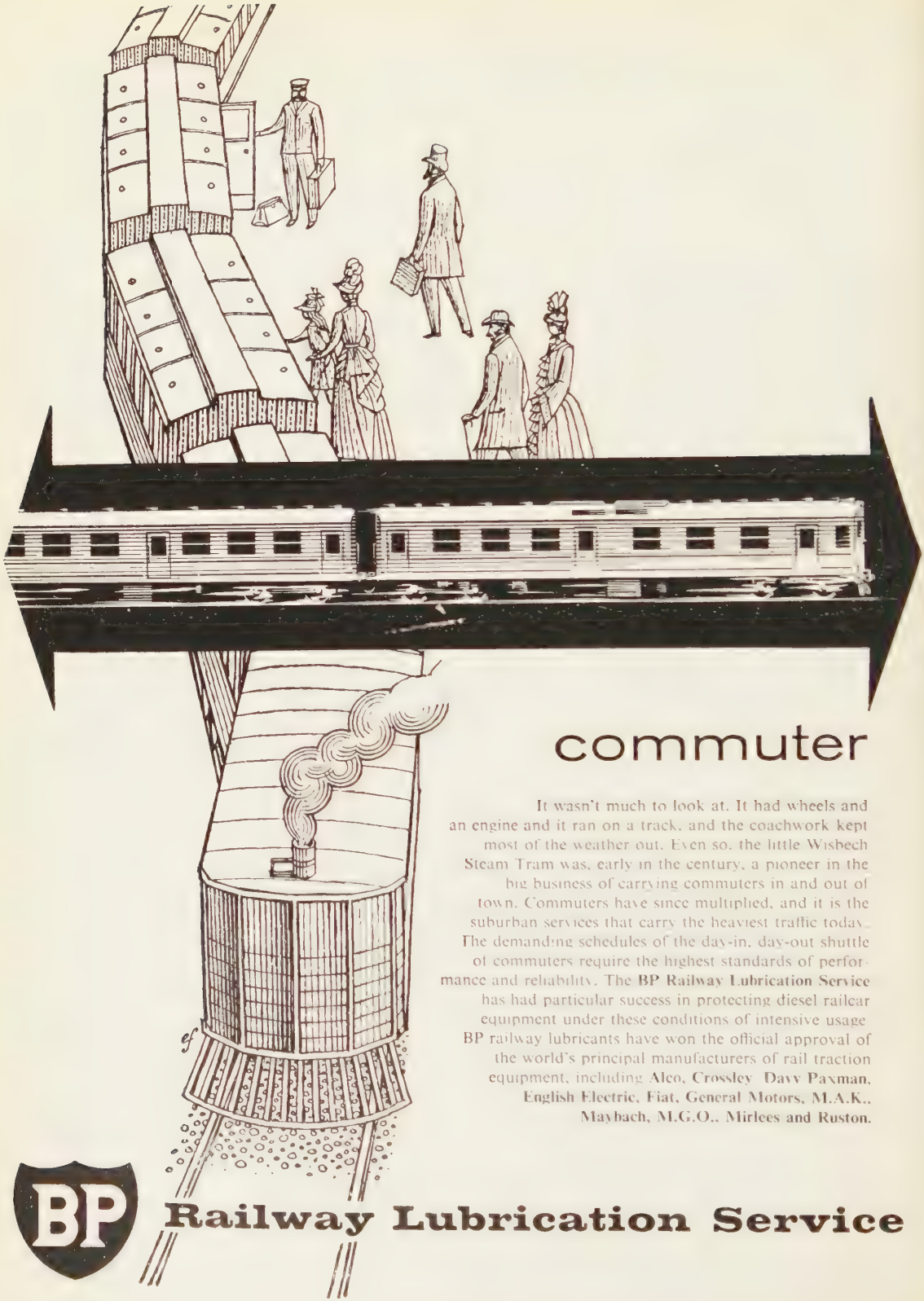

commuter

It wasn't much to look at. It had wheels and an engine and it ran on a track, and the coachwork kept most of the weather out. Even so, the little Wisbech Steam Tram was, early in the century, a pioneer in the big business of carrying commuters in and out of town. Commuters have since multiplied, and it is the suburban services that carry the heaviest traffic today. The demanding schedules of the day-in, day-out shuttle of commuters require the highest standards of performance and reliability. The **BP Railway Lubrication Service** has had particular success in protecting diesel railcar equipment under these conditions of intensive usage. BP railway lubricants have won the official approval of the world's principal manufacturers of rail traction equipment, including **Alco, Crossley Davy Paxman, English Electric, Fiat, General Motors, M.A.K., Maybach, M.G.O., Mirlees and Ruston.**

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MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

[385 (05]

VOL. XXXVIII. — 1961.

NOTICE TO READERS

LIST OF ABBREVIATIONS OF MEASURES, ETC., USED IN THE *BULLETIN*

Kilometre	km	Kiloampere	kA
Metre	m	Milliampere	mA
Centimetre	cm	Kilowat	kW
Square kilometre	km^2	Kilowatt-hour	kW h
Square metre	m^2	Watt	W
Square centimetre	cm^2	Megohm	MΩ
Hectare	ha	Ohm	Ω
Are	a	Ampere-hour	Ah
Centiare	ca	Microfarad	μF
Cubic metre	m^3	Henry	H
Cubic centimetre	cm^3	Weber	Wb
Stere	st	Hertz	Hz
Hectolitre	hl	Calory	Cal
Litre	l	Kilo-calory	kcal
Centilitre	cl	Lumen	lm
Degree	°	Lux	lx
Minute	′	Horse-power	HP
Second	″	Per cent	%
Tonne (Metric)	t	Per thousand	‰
Ton (English)	ton	Tonne-kilometre	tkm
Hundredweight	cwt	Passenger-kilometre	p.-km
Kilogramme	kg	Train-kilometre	tr.-km
Gramme	g	Miles per hour	m.p.h
Centigramme	cg	Franc	fr
Hour	h	Lire	L
Minute	min	Pound sterling	£
Second	s	Shilling	s.
Kilogrammetre	kgm	Penny	d.
Volt	V	Dollar	$
Millivolt	mV	Cent	ct
Kilovolt	kV	Deutsche Mark	DM
Ampere	A	Pfennig	pf

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR JANUARY 1961.

1961 **625** .233
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 1.
ARNAUD (P.) and LAMORLETTE (P.). — **A new type of generator equipment for the lighting of railway vehicles.** (2 200 words & figs.)

1961 **625** .2
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 10.
SPERLING (E.) and BETZHOLD (Ch.). — **Contribution to the study of the acoustics of vehicles.** (4 000 words & figs.)

1961 **656** .212 .5 (42)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 24.
New W.R. marshalling yard at Margam. Fully automatic operation. (3 900 words & figs.)

1961 **656** .225 (42)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 36.
Combined rail-and-road vehicles for British Railways. (2 000 words & figs.)

1961 **656** .22 (73)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 43.
LANG (A.S.). — **New goals for RR research.** (1 600 words.)

1961 **656** .25 (494)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 47.
Transportable signalbox on Swiss Federal Railways. (2 000 words & figs.)

1961 **656** .212 .6 (73)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 52.
Mail hoists cut train delays. (800 words & figs.)

1961 **656** .25 (73)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 55.
FLAMAGAN (P.A.). — **Planning the C & O's clic. — The economics of data communications.** (1 800 words & figs.)

1961 **625** .4 (73) & **656** .25 (73)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 66.
Subway trains route themselves. (1 600 words & figs.)

1961 **385** (02
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 74.
NEW BOOKS AND PUBLICATIONS. — **Directory of Railway Officials and Year Book, 1960-1961.** (300 words).

1961 **656** (06 (43)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 74.
NEW BOOKS AND PUBLICATIONS. — **Vorträge und Berichte der 3 Verkehrswissenschaftlichen Tage der Hochschule für Verkehrswesen Dresden.** *(Lectures and Reports of the Three « Science of Transport » Days held at the Dresden Higher Transport School)*. (300 words).

1961 **385** (08 (42)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 75.
NEW BOOKS AND PUBLICATIONS. — **London Transport in 1959.** (500 words).

1961 **385** (08 (492)
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 76.
NEW BOOKS AND PUBLICATIONS. — **N.V. Nederlandse Spoorwegen. Jaarverslag 1959.** *(The Netherlands Railways. Annual Report for 1959)*. (400 words).

1961 **656** .281
Bull. of the Int. Ry. Cong. Ass., No. 1, January, p. 76.
NEW BOOKS AND PUBLICATIONS. — **Twisting capacity of railway carriage structures.** *(Practical investigation of derailments)*, by P. KERESZTY. (400 words.)

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CONTENTS OF THE NUMBER FOR JANUARY 1961.

CONTENTS	Page.
I. A new type of generator equipment for the lighting of railway vehicles, by P. ARNAUD and P. LAMORLETTE	1
II. Contribution to the study of the acoustics of vehicles, by E. SPERLING and Ch. BETZHOLD	10
III. New marshalling yard at Margam. Fully automatic operation	24
IV. Combined rail and road vehicles for British Railways	36
V. New goals for RR research, by A.S. LANG	43
VI. Transportable signalbox on Swiss Federal Railways	47
VII. Mail hoists cut train delays	52
VIII. Planning the C & O's clic. — The economics of data communications, by P.A. FLANAGAN	55
IX. Subway trains route themselves	66

CONTENTS *(continued)*.	Page.
X. New Books and Publications :	
Directory of Railway Officials and Year Book, 1960-1961	74
Vorträge und Berichte der 3 Verkehrswissenchaftlichen Tage der Hochschule für Verkehrswesen Dresden *(Lectures and Reports of the Three « Science of Transport » Days held at the Dresden Higher Transport School)*	74
London Transport in 1959	75
N.V. Nederlandse Spoorwegen. Jaarverslag 1959 *(The Netherlands Railways. Annual Report for 1959)*	76
Twisting capacity of railway carriage structures *(Practical investigation of derailments* . by P. Kereszty.	76
XI. Monthly Bibliography of Railways	1

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An edition in French is also published.

Vol. XXXVIII. — No. 1. January 1961.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625 .233]

A new type of generator equipment for the lighting of railway vehicles,

by P. ARNAUD,
Ingénieur en Chef, Service du Matériel et de la Traction, Région Sud-Ouest, S.N.C.F.,
and P. LAMORLETTE,
Ingénieur en Chef à la Société « L'Eclairage des Véhicules sur Rails »,
(*Revue Générale des Chemins de fer*, March 1960.)

An old and difficult problem.

Although the heating and braking energy is supplied to the passenger coaches collectively, it has become an almost universal practice that, for purposes of electric lighting, the coaches are treated as self-contained units.

These coaches are therefore equipped with a source of energy, generally consisting in a generator driven by the axle, and an energy storage device, in the form of a battery, to ensure the current supply when the train is at rest. Because of the battery, it is necessary to use D.C.

The conventional equipment of a railway vehicle thus comprises a D.C. supply, driven by an axle and charging the battery. These conditions necessitate a rather special equipment, as the voltage must be suitably adjusted irrespective of the running speed of the coach, ranging from the lowest speeds to the highest (in France, 160 km/h), and the polarity must be the same, irrespective of the direction of running.

Moreover, trouble-free working under these conditions must be ensured without manual intervention, with reduced maintenance requirements, and under difficult climatic conditions, seeing that, in mid-winter, after a prolonged period of stabling in the sidings of a mountain terminal, the temperature of the equipment may drop to — 30° C, whilst during the summer, the fairing when exposed to the full sun, may reach temperatures of + 70° C.

For many years, these conditions, so difficult from the point of view of reliable automatic working as well as from the climatic point of view, have been met, on the whole, fairly satisfactorily. This is not really surprising, since railway technology has often paved the way for technical progress. It may be recalled that it was on the basis of train lighting techniques, that the well-known electromagnetic regulators were at one time developed which were subsequently destined to play an important part in the most variegated fields of electrotechnics.

This was, in particular, the case with the segment type B.B.C. regulator, built in Switzerland by the Brown Boveri Company, as well as with the mercury type D.I.C.K. regulators and, more recently, the electromagnetic E.V.R. comb type regulators. The carbon cell regulators, too, were mainly created for regulating the train lighting current generators and, though they have not found a very widespread range of applications in industry, are almost the only electromagnetic regulators still used in aircraft.

In keeping with its tradition, the train lighting technique is, to-day, among the foremost users of ultra-modern control techniques by transistors, magnetic amplifiers, and power rectifiers of the semi-conductor type.

New solutions were awaited.

Conventional equipment for train lighting generation and regulation has now been used for so long that one has nearly reached the end of all possible perfections. But the demands made on this type of equipment continue to increase, and can only with difficulty be met by equipment of conventional design.

The modernisation of the equipment of the coaches calls for an increase in the generating power. As a result, the generator can no longer be driven by flat belts, and it is necessary to envisage other devices such as V-belts or mechanical drives; the latter can, however, only be used economically if the generator is mounted on the bogie.

By placing the generator on the bogie, its working conditions are changed considerably. The shocks and vibrations to which the generator is exposed render commutation difficult, just when commutation is a particularly delicate problem on such a machine because of the absence of commutation poles and the wide speed range.

Whilst, previously, the flat belt which has a considerable angular flexibility, made it comparatively easy to mount the generator in the springborne part of the vehicle, it will be seen that the increase in power has, at the same time, resulted in an aggravation of the working conditions.

Simultaneously, with the mounting of the generator on the bogie, it has become even more desirable to reduce the weight of the machine, i.e. to make use of particularly efficient characteristics. True, these problems have been solved, but not always quite satisfactorily, since the inspection and maintenance requirements have been increased.

To make further progress, it would thus be necessary to approach a certain number of structural problems concerning the generator. It is for that reason that, in several countries, one has had the idea of replacing the D.C. generator by an alternator, i.e. a machine where the problem of polarity, and thus the problem of the

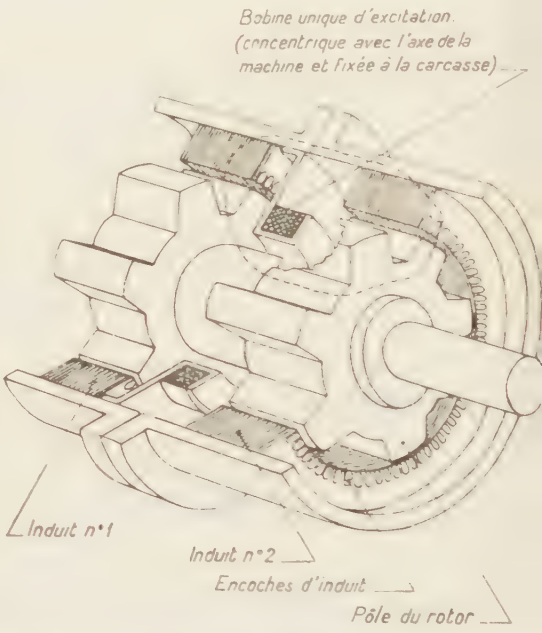
Bobine unique d'excitation (concentrique avec l'axe de la machine et fixée à la carcasse)
Induit n°1
Induit n°2
Encoches d'induit
Pôle du rotor

Fig. 1. — Single-pole two-armature generator. The broken lines indicate the path of the flux.

Explanation of French terms :

Bobine unique... = single excitation coil (concentric with the centre line of the machine, and fixed to the carcase). — Induit = armature. — Encoches d'induit = armature slots. — Pôle du rotor = rotor pole.

direction of running, does not arise. Similarly, the problem of commutation disappears, as the connection to the rotating conductors is provided by rings, i.e. by means of a sliding, non-commutating contact.

Why has such a solution not been envisaged earlier ?

First of all, because, as already mentioned, the conventional type of equip-

ment was perfectly suited to the problem then encountered.

Secondly, the need for rectifying the current produced by the alternator calls for the use of static rectifiers which, even a few years ago, were still too expensive and too bulky for this purpose. For a powerful equipment, one easily arrived at rectifier sizes of the order of magnitude of 1 cubic metre.

satisfactorily, but have not been widely used as the introduction of the current rectifier, whilst simplifying the problem of brushes and the design of the machine, did not eliminate the need for maintenance.

The Statodyne equipment.

In view of the advantages of these solutions, one type of equipment, known as

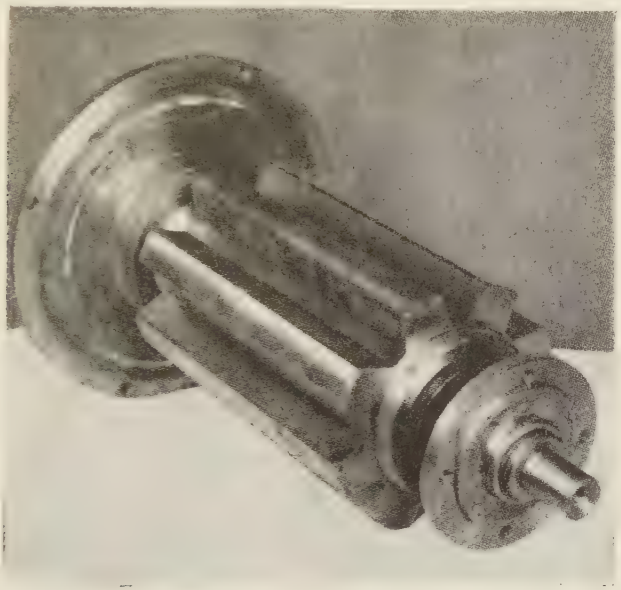

Fig. 2. — Statodyne rotor.

With the need to meet more exacting train lighting specifications and with the important progress simultaneously achieved in static rectifier techniques, the solution based on the use of alternators has now become an economic proposition.

In several countries, equipment has been designed where the energy is produced by an alternator which is fitted with rings and feeds a rectifier, generally of the selenium type. Regulation is ensured either by means of a regulator of the conventional type, or by means of devices with saturable chokes, controlled by iron-hydrogen lamps. These equipments work

« Statodyne », has been specially developed for the S.N.C.F. by one of their suppliers. This equipment, though based on the principle of current generation in the form of A.C. statically rectified, differs from all the conventional techniques in that the machine does not contain either ring or brush or commutator, or even a rotating winding. The rotor merely consists of a piece of steel of particular shape. On the stator of the machine are mounted the inductor windings and the armature. Inside the coach is a cabinet containing the power rectifier as well as the regulator which serves to keep the voltage constant, irres-

pective of the speed of rotation, within a running speed range from 30 to 160 km/h. This regulator itself is not one of the least interesting items of the equipment as it does not contain any moving organ, any relay, any vacuum or gas filled lamp, or any iron-hydrogen lamp; it merely consists of a magnetic amplifier unit controlled by a transistor type electronic unit.

With the exception of the ball bearings, no part of the equipment, either in the machine or in the cabinet, is subject to wear, or requires maintenance.

The generator.

The principle of the Statodyne generator is based on that of the revolving iron type alternators known as « single-pole two-armature » which were used at the beginning of the century for the generation of high-frequency current destined for radio-telephony transmitters. The principle of this old machine is recalled in figure 1.

The inductor mounted on the carcase causes the longitudinal and radial flow of a magnetic flux. The rotation of the rotor causes the flow paths of this flux to change in such a way that the armature conductors are alternately placed in a very strong field and in a very weak field so that they give rise to an alternating electromotive force. By means of patent-protected arrangements, the Statodyne generator makes use of a principle comparable to that of a single-pole two-armature alternator, but is of a much simpler design. The rotor illustrated in figure 2 is, in fact, a simple stack of sheets cut in the form of a toothed wheel.

Figure 3 shows the outward appearance of the Statodyne generator which is rather

Fig. 3. — Statodyne.

akin to that of conventional generators, but has no inspection door. It is, in fact, no longer necessary to provide access to the interior of the machine as there are no longer any brushes or rings.

Another advantage arises from the fact that the terminal box is placed on the carcase and not on the support as with conventional dynamos so that the inspection and lubrication of the two ball bearings do not call for any disconnection of cables.

manium appears to have little chance in this field because of the need for ventilation, but that silicon will certainly be of interest, especially for 72-96 V equipment.

Even so, the good performance and high efficiency of the selenium cells (as well as the constant progress in manufacturing technology) suggest that the selenium rectifier will, for many years to come, remain the best suited type for train lighting equipment of 24-30 V.

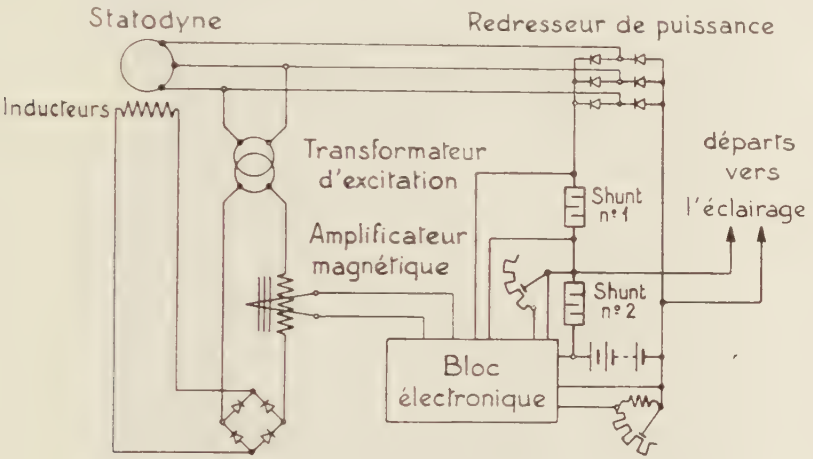

Fig. 4. — Germanium type exciter rectifier. Basic diagram.

Explanation of French terms :

Redresseur de puissance = power rectifier. — Inducteurs = inductors. — Transformateur d'excitation = excitation transformer. — Amplificateur magnétique = magnetic amplifier. — Bloc électronique = electronic unit. — Départs vers l'éclairage = to lighting circuits.

The power rectifier.

The power rectifier is of the selenium type. This choice may seem surprising at a time when the remarkable performances of new germanium or silicon semi-conductor type rectifiers permit a constantly widening range of applications. As it happens, however, probably due to the effect of competition, selenium has made such progress that it represents, to-day, the most economic and most reliable solution for powers of several kilowatts and for the low voltages required for train lighting.

It may be noted, in passing, that ger-

The regulator.

The excitation winding of the alternator requires a D.C. feed. This D.C. supply could of course be taken from the battery and could be controlled by any of the conventional methods, including in particular, an electromagnetic regulator. But this arrangement would have called for special measures to prevent the battery discharge to the inductors during standstill, and would have entailed the retention of movable parts. It was therefore preferred to use a magnetic amplifier.

It will be seen from figure 4 that the

alternator excitation is fed by means of a rectifier to the terminals of the alternator itself. This self-excitation automatically ensures the interruption of the inductor feed during stops and permits the introduction of a regulating device on the input side, i.e. the alternating side, of the excitation rectifier. An alternating current can be more easily controlled, statically, which resembles a transformer. One will note the absolutely passive character of this equipment and the robustness which can be achieved by normal impregnating methods, casting in plastics, etc.

A transistor type electronic amplifier is connected between the battery and the control winding of the magnetic amplifier (cf. diagram fig. 4).

Fig. 5 — Magnetic amplifier.

than a direct current. It is, in fact, sufficient to introduce a choke, the reactance of which is controlled by injecting more or less direct current into a special winding known as « control winding ». The very remarkable feature of this saturable choke (also known as magnetic amplifier) is that the power consumed by this control winding is much lower than the power liberated or blocked by the amplifier.

If, for example, a Statodyne requires an excitation power of 200 W, the circulation of this excitation power of 200 W can be controlled by a control power much smaller than 1 W.

Figure 5 shows the magnetic amplifier

It measures, on the one hand, the voltage at the battery and lighting circuit terminals and, on the other hand, the total current output of the alternator, by means of shunt No. 1, figure 4. Depending on whether these values are found to be slightly lower or higher than the ideal values required, the regulator makes available a control current of greater or smaller intensity which, by means of the magnetic amplifier and the alternator excitation, automatically and instantaneously causes the desired correction.

If the battery used calls for a charging rate lower than the maximum output of the alternator, the electronic amplifier is

ble to add, to the voltage regulation and o the limitation of the total alternator utput, a second limitation acting on the harging current of the battery, by means f shunt No. 2, figure 4. With this supplementary limitation, it is possible to ensure he charging of a lead battery under the est conditions.

equipment is in keeping with what is normally understood by « railway » equipment. All the circuits are packaged into a single unit where the circuits are completely embedded and enveloped in an extremely robust plastic material. Figure 6 shows the outward appearance of such an electronic amplifier.

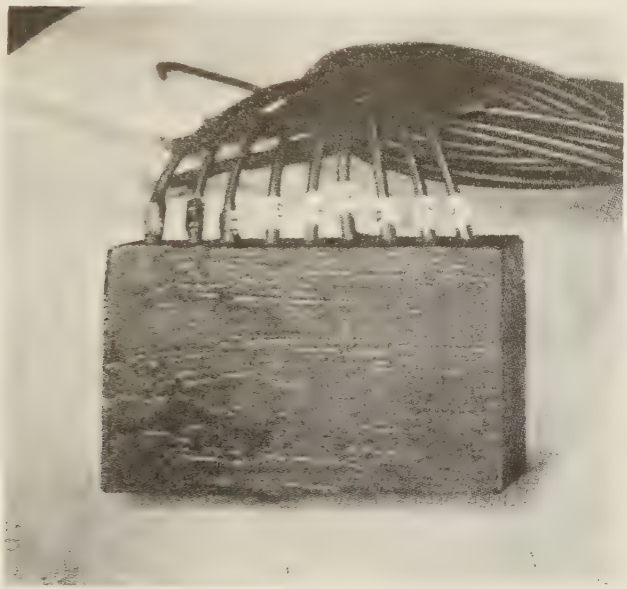

Fig. 6. — Transitor type electronic amplifier.

These different functions could only be ulfilled by an electronic amplifier. This levice, measuring the battery voltage, is ermanently connected with the battery; here is thus a slight permanent current onsumption, and it is desirable to keep his current as light as possible so that he battery is not discharged during proonged stops. Due to the electronic amplification, this current can be reduced to a few milliamps, i.e. to a value much below he natural losses of battery capacity.

The electronic amplifier comprises such rgans as transistors, micro-resistances, etc. Neither the size nor the design of this

Working characteristics.

The rated performance of the first equipment built is in keeping with the S.N.C.F. specifications for the equipment of regional train services, viz. :

— voltage 24-30 V from a battery with twelve lead cells or nineteen cadmium-nickel cells;

— nominal current : 110 A;

— speed at full output : 600 r.p.m.;

— maximum speed : 3 000 r.p.m.

With these characteristics, the equipment is able to provide its full power for all speeds comprised between 32 and 160 km/h.

Figure 7 shows the overall characteristics of this regulation. The curves are shown for three speeds : 700, 1 500 and 3 000 r.p.m. It will be seen that the variation in speed causes a very slight scatter of the voltage at the battery terminal at the end of the charging period, and of the total current delivered by the equipment to the battery, to the lighting circuit, and to the low-tension heating circuit. Where the regulator is fitted with the supplementary shunt shown as No. 2 in figure 4 (lead battery), the maximum current absorbed by the discharged battery is limited as shown by the second family of curves.

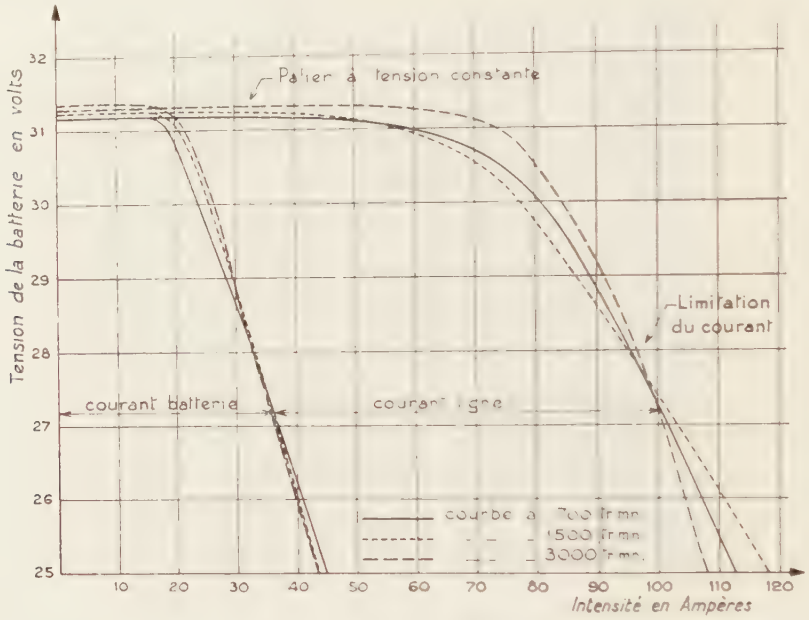

Fig. 7. — Working characteristics.

Explanation of French terms :

Courbe à 700 tours/min = curve for 700 r.p.m. — Intensité en ampères = amperage. — Tension de la batterie en volts = battery voltage. — Palier à tension constante = constant voltage level. — Courant batterie = battery current. — Courant ligne = line current. — Limitation du courant = current limitation.

Conclusions.

The electric coach lighting equipment of the Statodyne type is thus particularly simple, as it merely comprises :

— the A.C. generator shown in figure 3, with non-wound rotor, without brushes or rings, without inspection door;

— the unit shown in figure 8, measuring no more than 640 × 450 × 235 mm so that it is mounted in a cabinet inside the coach. It comprises, on the left, the connection terminals; in the centre, the selenium type power rectifier with its cooling blades; on the right-hand side, enclosed, the transformer and exciting current rectifier, the magnetic amplifier shown in figure 5 which regulates the current under the control of the transistor type electronic amplifier unit shown in figure 6. The unit is calibrated at the test bench by means of two potentiometers, one for the voltage at the end of the charging period, the other

or the maximum charging current supplied o the units, which limits the batterv harge;

— the battery, which may be of the cad- nium-nickel or lead type;

The low-tension heating equipment which is fed by D.C., is of course not affected.

In 1958, some 50 Statodyne equipments were commissioned by the S.N.C.F. This small series was preceded, in 1957, by a

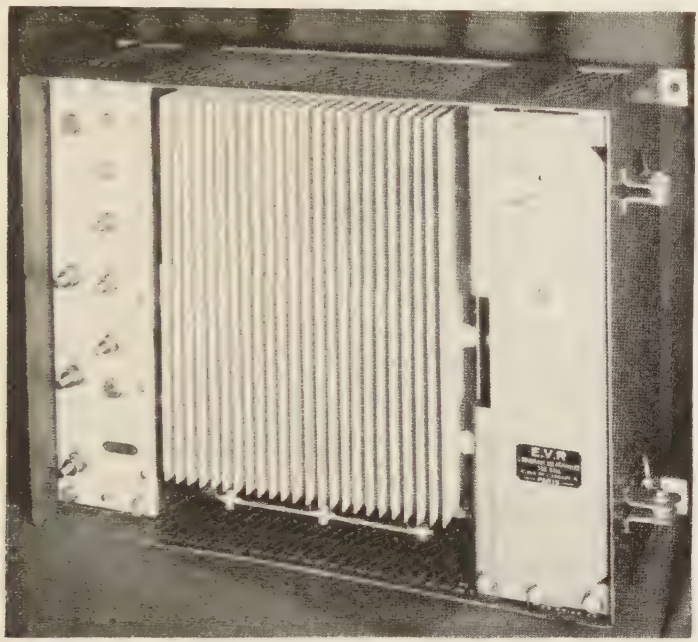

Fig. 8. — Statodyne regulating and current rectifier unit.

— finally, a lamp regulator of the con- entional type which keeps the voltage at heir terminals within very narrow limits n order to obtain a constant lighting effect s well as a long service life of the lamps.

prototype equipment which has now cover- ed 500 000 km.

Experience suggests that the characteris- tics of this equipment will have the effect of virtually eliminating maintenance work.

Contribution to the study of the acoustics of vehicles

(Note from the rolling stock testing department of the Bundesbahn),

by Bundesbahnoberrat Dr.-Ing. E. Sperling

and Dr. rer. nat. Ch. Betzhold, Minden (Westphalia.)

(*Glasers Annalen*, No. 10, October, 1959.)

The arrangements made to improve the acoustics of railway rolling stock not only improve the comfort of the journey but in a certain sense increase the safety.

Amongst the multitude of acoustical problems raised in the construction of vehicles, we are only going to deal with two particularly typical problems which have only been the subject of tests on railway vehicles but the results obtained are by analogy equally applicable to road vehicles. On the one hand, there is the question of the influence of the components of noise transmitted through the air and through the solid parts on the interior running noises, and on the other hand, the effectiveness of silencers on motor vehicles.

1. Influence of the components of air noises and the noise of solid matters on the interior running noise.

What matters first of all as far as the builder is concerned is the total amount of interior noise during running. The first question which arises is the following : how many phons are produced and what will the subjective judgment of the passenger be ? This is a relatively simple problem : the measuring apparatus must comply with the DIN 5045 standards, the subjective judgment is established from the results of the measurements and values obtained from experience which we have empirically fixed (see Table 1).

The second question, however, which is a much more interesting one, is framed like this : how can the vehicle be improved from the acoustical point of view ? At what point must we take such steps ? For this purpose it is necessary to make a great many measurements at different places in the vehicle (both inside and outside) under various exterior conditions (noisy or quiet track). The analyses of the frequencies recorded on the recording band are often sufficient to give a lead. But the problem is only clarified when the components of the noise transmitted through the air and through the solid masses are really separated. From the metrological point of view, such a separation is not possible, on the one hand because the microphones pick up all the components of noise transmitted through the air, because these components come directly into the vehicle through the windows, etc., or else are radiated by the floor in the form of noise transmitted through solid masses. It is possible however to attain the desired end in a relatively simple way by means of a given choice of the points at which measurements are taken; one such method is described below.

It is supposed that in the centre of the vehicle we get, in the case of the vehicle under test in question, the following measured values in the case of a noisy track (with undulatory wear = mR) and a quiet track (without undulatory wear = oR) at a speed of 80 km (50 miles)/h :

noise from outside air :

A_{oR} (dB) and A_{mR} (dB);

total interior noise :

L_{oR} (dB) and L_{mR} (dB);

noise of solid masses at floor level :

K_{oR} (dB) and K_{mR} (dB).

TABLE 1. — **Indexation of interior running noises in passenger coaches.**

Physiological intensity (DIN phons)	Note (Index)	Aural intensity (sones)	Appreciation	Fatigue time T (h)
0	—	—	Barely audible	—
50	1.0	2.2	Very good (very weak)	more than 24
57.5	1.5	3.9	Very good to good	
65.0	2.0	6.8	Good (weak)	
72.5	2.5	12.2	Good to satisfactory	13.0
80.0	3.0	21.5	Just satisfactory (admissible)	5.6
87.5	3.5	38.4	Just bearable	2.8
95	4.0	68.0	Inadmissible	1.5
120	—	—	Becoming painful	—

This index diagram applies to the average noise produced on a long section of track and for a central compartment at V = 80 km/h

We endeavour to find respectively the components of noise transmitted through the air P_{oR} (dB) or P_{mR} (dB) and the components of noise from solid masses x K_{oR} (dB) or x K_{mR} (dB) (1) making up the total interior noise; it is admitted that these consist of the above factors as follows :

P_{mR} (dB) plus x K_{mR} (dB) gives L_{mR} (dB) (1)

P_{oR} (dB) plus x K_{oR} (dB) gives L_{oR} (dB) (2)

In these relations x is the factor converting the noise from solid masses into noise transmitted through the air which is taken as being equal in the case of noisy track (mR) and quiet track (oR). It is a question of calculating the components P_{mR}, P_{oR}, as also x K_{mR} and x K_{oR}.

With the aid of the well known equation :

$$L = 20 \log \sqrt{\frac{p_1^2 + p_2^2 + \dots}{p_o}}$$

for adding up the sonorous pressures, and under the hypothesis that when passing from quiet track to noisy track the interior noise increases to the same extent as the outside noise : $P_{mR} - P_{oR} = A_{mR} - A_{oR}$, we can convert the equations (1) and (2) into :

$$L_{mR} = 20 \log \frac{\sqrt{4 \cdot 10^{-8} \cdot 10^{0.1\,P_{mR}} + x^2 \cdot 10^{0.1\,K_{mR}}}}{2 \cdot 10^{-4}} \quad (3)$$

$$L_{oR} = 20 \log \frac{\sqrt{\frac{4 \cdot 10^{-8} \cdot 10^{0.1\,P_{mR}}}{10^{0.1(A_{mR} - A_{oR})}} + x^2 \cdot 10^{0.1K_{oR}}}}{2 \cdot 10^{-4}} \quad (4)$$

Resolving these equations with reference to x^2 and by equalising, it becomes :

$$P_{mR} = L_{mR} + 10 \log [1 - 10^{0.1(L_{oR} + K_{mR} - L_{mR} - K_{oR}]} - 10 \log [1 - 10^{0.1(A_{oR} + K_{mR} - A_{mR} - K_{oR}]} \quad (5)$$

(1) In the case of noise transmitted through the air dB per 2.10^{-4} μbar, for the noise from solid masses dB per cm s^2.

By a development in series and other transformations, we get from the relation (5) the following close solutions for the values required (2) :

$$P_{mR} \approx L_{mR} + \frac{4.3}{10^{0.1(A_{mR} - A_{oR}) - (K_{mR} - K_{oR})}} - \frac{4.3}{10^{0.1(L_{mR} - L_{oR}) - (K_{mR} - K_{oR})}} \quad (6)$$

$$P_{oR} \approx P_{mR} - (A_{mR} - A_{oR}) \quad (7)$$

$$x\ K_{mR} \approx L_{mR} - \frac{4.3}{10^{0.1(L_{mR} - P_{mR})}} \quad (8)$$

$$x\ K_{oR} \approx L_{oR} - \frac{4.3}{10^{0.1(L_{oR} - P_{oR})}} \quad (9)$$

The expression $f(y) = 4.3^{-0.1\ y}$ which recurs in the calculation can easily be determined by means of a numerical scale (see fig. 1) and be included in the above equations.

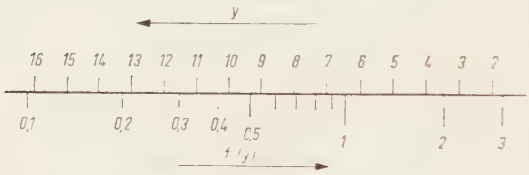

Fig. 1. — Scale of values for :
$f(y) = 4.3 \cdot 10^{-0.1\ y}$.

A few characteristic examples are grouped together in Tables 2 and 3; the results are considered below.

The vehicle AB 4üm 11827 is a coach for a long distance train, in first class order : component L and component K give the total noise :

for noisy track :

77 dB and 77 dB giving 80 dB;

for quiet track :

56 dB and 73 dB giving 73 dB.

The ceiling is perforated; this ceiling, insulated above by a layer of flock with the wide air space below it, ensures good absorption of the noise, especially above 500 Hz; the relatively wide difference between the values of measurements in dB and in DIN phons must be attributed to this fact. On a good line (quiet), it is the components of noise from solid masses that predominate. If a further reduction of the interior noise level is justified economically, it is above all the sonorous level of noise from solid masses that must be reduced.

Another example is that of measurements made in the centre coaches of TEE rakes.

Coaches with separate compartments :

component L and component K give the total noise :

in the case of noisy track :

89 dB and 89 dB giving 92 dB;

for quiet track :

75 dB and 84 dB giving 85 dB.

Coach with one big compartment :

in the case of noisy track :

92 dB and 92 dB giving 95 dB;

for quiet track :

79 dB and 86 dB giving 86 dB.

The TEE rakes generally consist of two motor units, two coaches with separate compartments, one coach with one big

(2) The authors thank M. G. BUSCHMANN, Dipl.-Eng., for his suggestions.

TABLE 2. — **Examples for the determination of the noise components transmitted through the air and through the solid masses in the total noise in passenger coaches** (mR/oR).

Amount	Value	AB 4 üm 11827 coach with separate compartments	TEE coach with separate compartments	TEE coach with one large compartment
Values measured :				
A_{mR}/A_{oR}	dB	113 92	129/115	129/115
L_{mR}/L_{oR}	dB	80 73	92/85	95/86
l_{mR}/l_{oR}	phons DIN	66 56	82/73	90/78
K_{mR}/K_{oR}	dB	41 36	36/30	38/30
Components calculated:				
P_{mR}/P_{oR}	dB	77 56	89/75	92/79
xK_{mR}/xK_{oR}	dB	77 73	89/84	92/86

TABLE 3. — **Example for the determination of the components of noise transmitted through the air and through the solid masses in the total noise of the V 60101 Diesel locomotive (full load/running light).**

Values measured :		
Machinery compartment	(A)	115 dB/110 dB
Driving compartment	(L)	98 dB/ 96 dB
Driving compartment	(l)	87 phons DIN/82 phons DIN
Floor	(K)	59 dB_K/53 dB_K
Components calculated :		
Components of noise transmitted through the air.	(P)	93 dB/ 88 dB
Components of noise transmitted through the solid masses	(x K)	97 dB/ 95 dB

compartment with adjustable seats, as well as a restaurant car and a kitchen car. These first class vehicles provide a very comfortable journey : seats with adjustable headrests, pleasant modern lighting, complete air conditioning, etc. But a comfortable journey also requires very steady running and a reduced noise level.

The many new technical inventions have introduced considerable improvement in this field and have thereby justified themselves; yet in other fields it has been necessary to put up with certain drawbacks (for example as regards the production of noise).

The object of the design and of the sound proofing was to make up for additional difficulties in the acoustical field.

In the middle compartments, the noise level is low (less than 70 phons); the subjective evaluation is therefore between good and satisfactory.

Separating the components of the noise transmitted through the air from those of the noise transmitted through the solid masses

shows that on a noisy track these components are equal and on quiet track, the noise from the solid masses predominates. The higher level of these latter is due in part to the small length of the coaches. Attempts to reduce the noise still more should be turned above all towards reducing the conduction and radiation of noise from solid masses.

The acoustic devices used on the V 60 diesel locomotives are shown in figure 2.

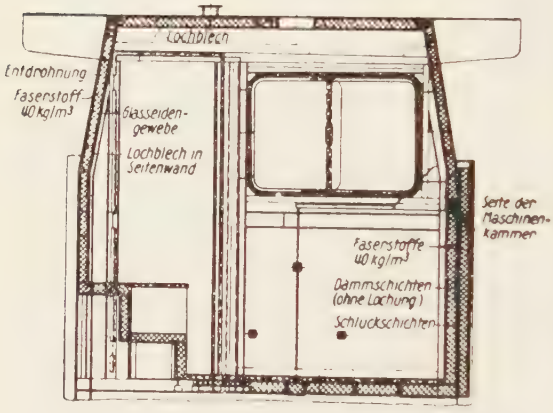

Fig. 2. — Longitudinal section through the driving compartment of a V 60 shunting Diesel locomotive.

N.B. — Entdröhung = antivibrationary. — Faserstoff = fibres. — Glasseidengewebe = glass silk tissue. — Lochblech in Seitenwand = perforated sheet in side walls. — Seite der Maschinenkammer = machinery compartment side. — Dämmschichten (ohne Lochung) = damping out linings (without perforations). — Schluckschichten = absorbant linings.

The method dealt with above could also be applied to the noise arising in the driving compartments of the Diesel locomotives, bearing in mind that here it is not the influence of the track but that of the working conditions which matters :

Running light :

components L and component K give the total noise :

88 dB and 95 dB giving 96 dB;

and under full load :

93 dB and 97 dB giving 98 dB.

Both when running light and when running under full load, therefore the component of noises transmitted from the solid masses is higher than the actual components of noise transmitted through the air. This is what might be expected, seeing that on Diesel locomotives there are a great many bridges over which the noise transmitted from the solid masses can pass between the engine, the transmission, the auxiliary groups and the driving compartment. In addition to sound-vibratory deadening of the plates, other steps should be taken to reduce the level of noise due to the noises of solid masses in the driving compartment. In the new V 100 locomotive, the engine and the silencer have also been mounted on insulating devices; other improvements are projected, but the studies are not yet completed.

Figures 2 and 3 show the sound insulation devices used on the new V 60 and V 80 Diesel locomotives.

The insulation of the driving compartment has been the subject of particular care. A sufficient damping out of the noise transmitted through the air and the noise from solid masses as well as additional absorption of the noise has been obtained by combinations of mineral fibres, antivibratory materials, layers of sound deadening materials and perforated sheets. In addition, other measures have been applied in the case of the engine, the transmission, the fan and the exhaust. The exhaust silencers are the subject of special considerations.

2. **Silencers.**

The propagation of sound waves in pipes or ducts filled with gas or air can be reduced by means of silencers. The following considerations apply solely to silencers for combustion motors. The exhaust gases have to be evacuated without obstruction through the exhaust pipe of the motor; the noise superposes itself on this continuous flow under the form of an alternating flow. Sound deadening must reduce and if possible even

cut out the alternating vibration without impeding the continuous flow; the power of the motor must not be reduced by great back pressure because of the fitting of the silencer in the exhaust pipe. Nor must it be forgotten that in the case of the noise due to the exhaust, considerably lower frequencies are encountered than the firing frequency.

Figures 4 and 5 reproduce analyses of the exhaust noises of a 1 100 HP motor without any damping out of the noises. The motor has been studied with and without a silencer. For example, the silencer was replaced by a smooth tube 8.5 m long and 250 mm in diameter, in order to create comparable conditions.

The particularly characteristic frequency components are, under full load :

firing frequency :

150 Hz,

exhaust frequency :

28, 38, 76, 97 Hz,

components in the flux of gases :

18, 25, 35, 150 Hz.

The firing frequency can easily be calculated from the speed of rotation, the number of strokes and number of cylinders. The exhaust frequencies, which at times are definitely lower, can be calculated by approximation as follows : (3)

$$f_A = \frac{c}{2\pi}\sqrt{\frac{F}{V(l + 0.89\sqrt{F})}}$$

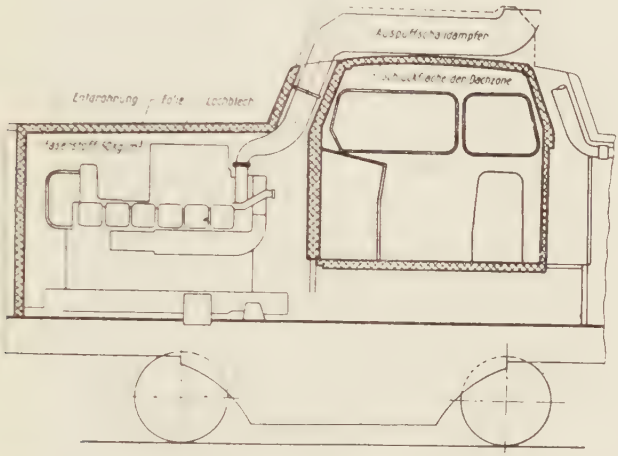

Fig. 3. — Fight against noise on the V 80 Diesel locomotive.

N.B. — Auspuffschalldämpfer = exhaust silencer. — Schluckfläche der Dachzone = absorbant surface of the roof area. — Folie = thin sheet. — Lochblech = perforated sheet. — Faserstoff = fibres.

in which :

V (m^3) = cylinder;

l (m) = length of exhaust pipe;

f (m^2) = area of exhaust pipe;

c (ms^{-1}) = speed of exhaust gas wave.

The effect of the silencers also depends on the ratio between the dimensions of the section of the silencer and the length of the

(3) Cf. MORRISON : Proceed. Ins. Autom. Engineers, Feb. 1940, and G.W. VAN SANTEN : Mechanische Schwingungen (Mechanical vibrations), Eindhoven, 1954.

noise wave to be damped out. It is therefore necessary to know the scale of frequencies of the noise to be damped out, the temperature, the chemical composition of the flux of gas, and the importance of the minimum damping out required in order to be able to decide

N_2 about 82 %;
CO_2 about 9 %;
O_2 about 8 %;
CO about 1 %.

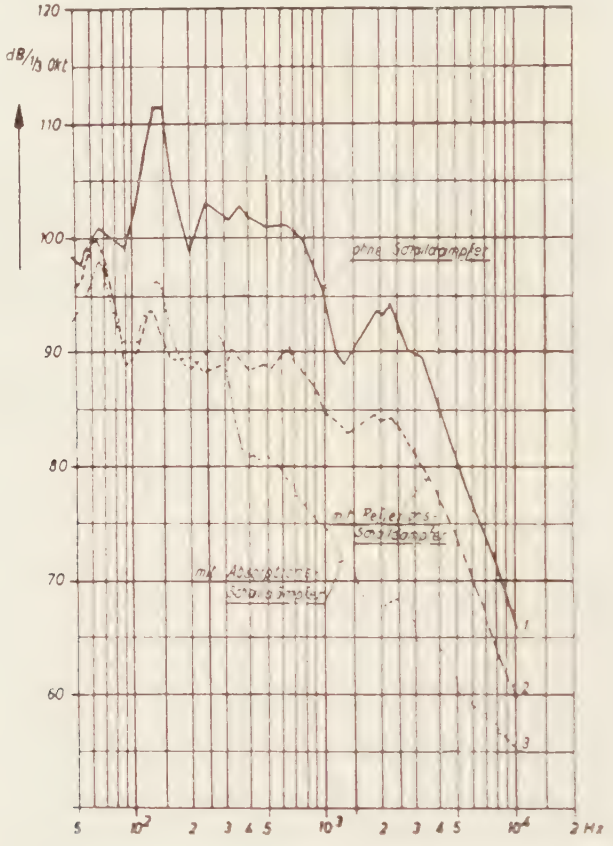

Fig. 4. — Spectres of the noise transmitted by the air in the exhaust of the 1 100 HP Diesel traction engine.

N.B. — Ohne Schalldämpfer = without silencer. — Mit Absorptionsschalldämpfer = with absorption silencer. — Mit Reflexionsschalldämpfer = with reflection silencer.

what type and size of silencer would be best.

In the case in question, the analysis of the gas (dry) gave the following approximate results :

The temperature of the flux of gases was on the average 500°, so that the speed of the wave could be expected to be N_2 (500° C) = 565 m s^{-1}.

Using these values in the above formula, we get an exhaust frequency of 27 Hz and pipe frequencies of 17, 35, 70 and 105 Hz, which agree in an acceptable fashion with the values measured above.

does not coincide with the frequency of the resonance after the silencer :

$$\left[f \quad \frac{c}{2l} ; \frac{2c}{2l} ; \frac{3c}{2l} \ \ldots\right]$$

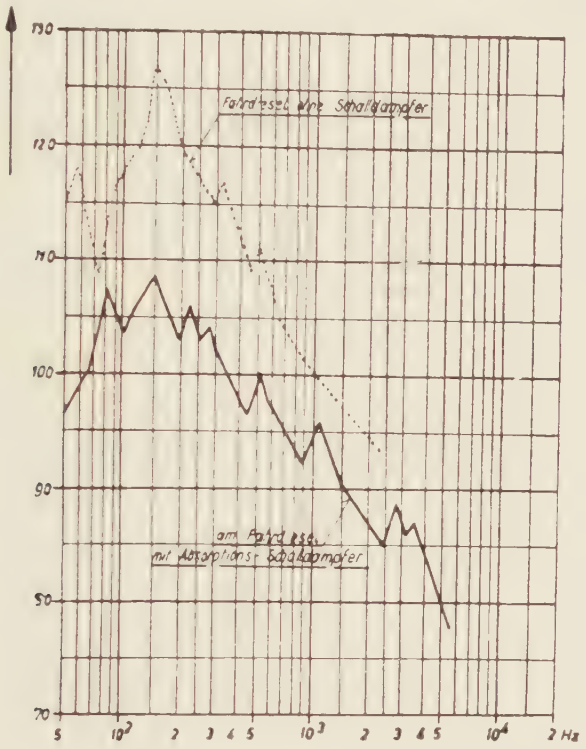

Fig. 5. — Spectres of noise transmitted by the air in the exhaust of the VT 11 5009 railcar.

N.B. — Fahrdiesel ohne Schalldämpfer = traction Diesel without silencer. — Am Fahrdiesel mit Absorptionsschalldämpfer = on the traction Diesel with absorption silencers.

Both as regards damping out and losses of power, the position of the silencer in the pipe is important. The position of the silencer must be chosen in such a way that the resonance frequency in front of the silencer, in other words between the motor and the silencer :

$$\left[f \quad \frac{c}{4l} ; \frac{3c}{4l} ; \frac{5c}{4l} \ \ldots\right]$$

It is therefore necessary to take into account the design of the motor installation in order to place the silencer in an acoustically logical way.

The damping out counted on in theory is rarely obtained in practice owing to the inevitable places over which the noise can travel (between the walls and supports of the silencer) even when this defect is largely

remedied by reducing considerably the the transmission of the noise from the solid masses of the silencer cover and the walls through inserting intermediate sound deadening layers.

A distinction can be made between the following different types of silencers :

absorption silencers,
resonators,
reflection silencers,
interference silencers.

materials increases with the frequency, such silencers are useful above all in the case of high frequencies.

The preliminary calculation of the length needed for the damping out area for a given coefficient of absorption of the covering can be done by means of the formula given below, which gives the damping out of the pipe related to the unit of length as a function of the ratio of the damping out perimeter to the section of the pipe remaining free.

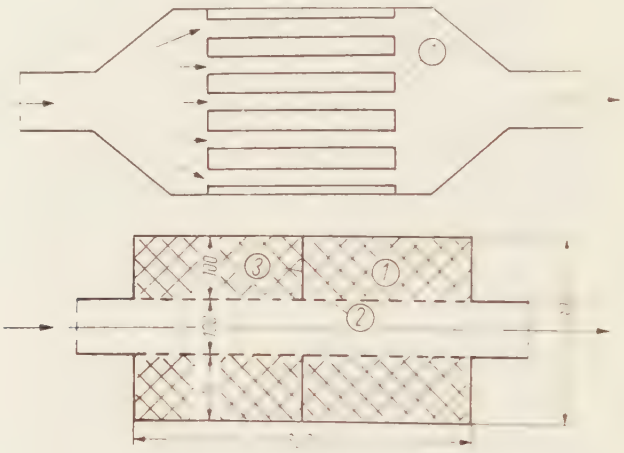

Fig. 6. — Absorption silencers.

(1) Absorbant material.
(2) Perforated sheet.
(3) Transversal subdivision.

2.1. *Absorption silencers.*

In the case of absorption silencers, the noise is to some extent converted into heat by friction on porous materials (asbestos, mineral wool, metal wool, etc.); some of the sonorous energy is thus taken over from the flux of gases; the noise is absorbed (see fig. 6).

The effectiveness of absorption silencers is a function above all of the coefficient of absorption of the covering used, and the size of the area and section conducting the noise. As the absorption effect of porous

This formula according to PIENING gives satisfactory results :

$$D_1 \text{ (dB/m)} = 1.5 \frac{U}{F} \alpha \qquad (10)$$

in which :

U (m) = perimeter of pipe with absorption covering;
F (m^2) = section of pipe remaining free,
α (—) = coefficient of absorption.

It is therefore always necessary to find a compromise between the acoustic effect of having a large perimeter of the damping out channels and the aerodynamic effect of

small values of U/F (according to O. GERBER and W. RICHTER, the above approximation does not apply in the case of high speed fluxes).

On the « Theodor Heuss » ferry-boat, the space available made it possible to fit each of the twelve propulsion Diesel engines with a sufficiently large silencer. The dimensions and type of absorption silencers used are shown in figure 7. Their effectiveness and the elastic mounting, used here for the first time, of 1 200 HP engines and the exhaust pipes play a very large part in the remarkably low noise level achieved.

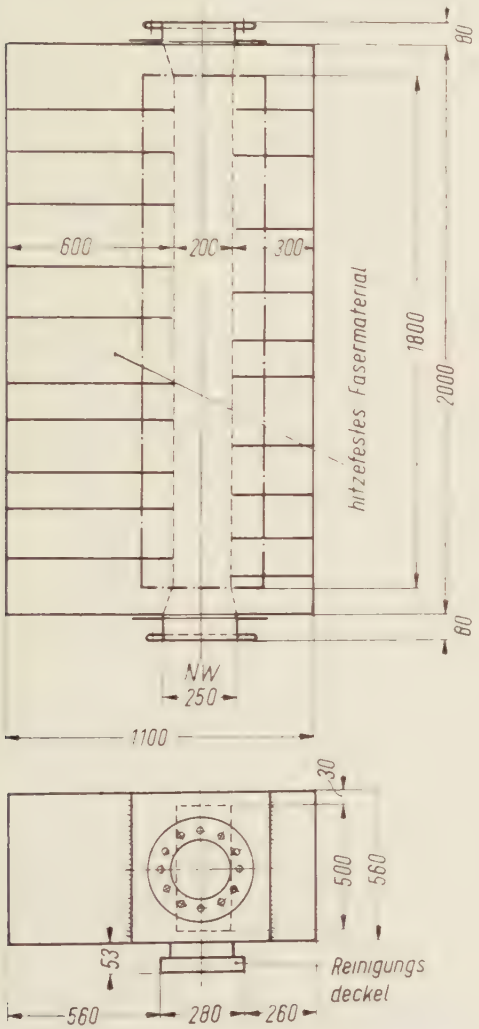

Fig. 7. — Absorption silencers for 1 200 HP Diesel used on boats.

N.B. — Hitzefestes Fasermaterial = heat resisting fibres.
Reinigungsdeckel = cover for cleaning.

Measurements taken of the noise at the exhaust outlet showed the very low value of 100 DIN phons, whereas without silencers an intensity of 130 DIN phons were measured on these 1 200 HP engines. The absorption silencers therefore led to a reduction in the noise level of 30 DIN phons.

On the motor car carrying deck the sound level amounts to 73 to 75 DIN phons and is consequently below the 85 DIN phons authorised by the Highway Code. On the railway deck bridge, the noises of the ship are more intense and reach a maximum of 90 DIN phons, but there is no fear of this impeding work on the bridge. In the passenger areas (restaurant and saloon) levels of only 55 to 70 DIN phons have been

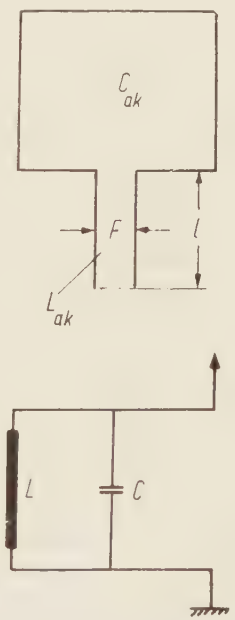

Fig. 8. — Helmholtz resonator and acoustic analogue.

measured; these results must be attributed to the effectiveness of the silencers and measures taken to damp out the noises transmitted through the air and the solid masses.

2.2 *Resonators.*

Hollow spaces with a small opening are known as hole resonators or as Helmholtz resonators (cf. fig. 8).

The air in the neck of the resonator must be considered as an incompressible mass (acoustic inductance) and undergoes an alternating displacement according to the rhythm of the sonorous frequency; the larger space, the chamber beyond the neck, acts like a spring (acoustic capacity). The absorption effect of resonators is due to the friction on the walls of the air vibrating in the neck. The frequency of the resonator itself is :

$$f_o = \frac{1}{2\pi}\sqrt{\frac{1}{L_{ak} \cdot C_{ak}}} \qquad (11)$$

L_{ak} = acoustic inductance,

C_{ak} = acoustic capacity.

The resonator damps out incidental noise to the extent that its own frequency is more or less equal to that of the noise in question. In practice, it is possible to make and fit resonators of this type for the scale of frequencies between 50 and 400 Hz approximately. The frequencies of the resonators themselves can be calculated from their dimensions :

long neck :

$l > R$ (for example, bottle shaped)

$$f = \frac{c}{2\pi}\sqrt{\frac{\pi R^2}{Vl}} \qquad (12)$$

short neck :

taking into account correction of the mouthpiece) :

$l < R$ (perforated platform, for example) :

$$f = \frac{c}{2\pi}\sqrt{\frac{\pi R^2}{V\,(1 + [\pi/2]R)}} \qquad (13)$$

with no neck :

$l = 0$ (perforated sheet for example) :

$$f = \frac{c}{2\pi}\sqrt{\frac{2R}{V}} \qquad (14)$$

R = radius of the opening,

l = length of the neck,

V = volume of the chamber,

c = speed of the wave.

If several resonators are arranged very close to each other along a tube, we must expect to get connections between the resonators along the actual pipe, which may considerably reduce their effectiveness.

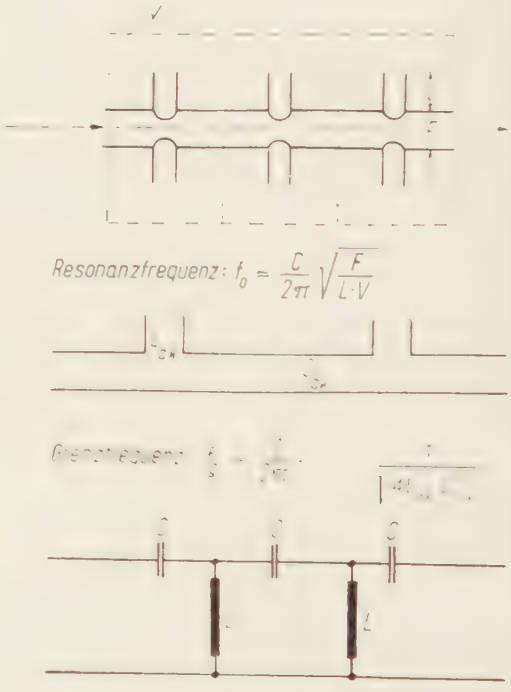

Fig. 9. — Low pass acoustic filter and corresponding analogous electrical filter (chain of condensators).

N.B. — Resonanzfrequenz = resonance frequency. — Grenzfrequenz = limit frequency.

Vibrating plates, another way of reducing the vibrationary energy, have actually never been used in the designing of silencers.

2.3. *Reflection silencers.*

Reflection silencers are based on the idea that the noise set up is to some extent reflected by an incorrect adaptation of the coupling

From the point of view of the effect, a distinction is made between filters in series which act in principle as filters cutting out high waves, and filters in parallel which can cut out either the high waves or the low waves.

The regulation of these filters determines the proper limiting frequency and consequently the scale of effective frequencies.

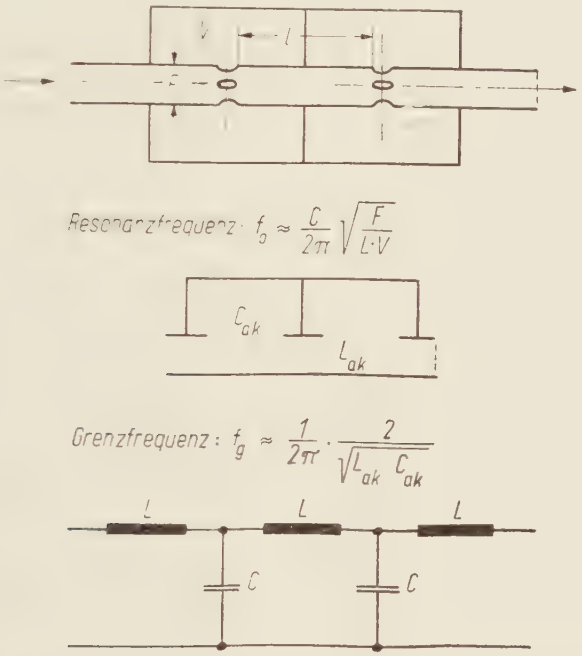

Fig. 10. — Low pass acoustic filter and corresponding analogous electric filter (chain of inductances).

points. The damping out of noise in the pipe is obtained by means of acoustic reactances. Incorrect adaptation may be caused either by acoustic resistances (filters in parallel) or by resistances in series with the main pipe (filters in series). If the arrangement is repeated in a regular succession, it is said to be an iterating system or acoustic filter. The properties of acoustic filters are analogous to those of electric filters, which are simply mentioned in passing.

Filters in series (chains of condensators, see fig. 9) must be set to a frequency which is less than half the frequency to be damped out, whilst it is agreed that filters in parallel (chains of reactances, see fig. 10) must be in the scale of frequencies to be damped out.

With low pass filters in echelon, each resonator has different dimensions, but the same frequency; in this way the formation of disturbing stationary waves is avoided. In principle, the transversal dimensions of the

filters should at the maximum equal half the length of the sound wave to be damped out.

Figure 11 is a section of a reflection silencer for exhaust gases intended for use on a 230 HP Diesel engine (auxiliary Diesel on the TEE rake). The flux of gases first of all passes through a filter in series and then through a filter in parallel. This reflection silencer has been found to be particularly effective between 100 and 1 000 Hz. The total level of the exhaust noise has been brought down to approximately 115 to 100 DIN phons.

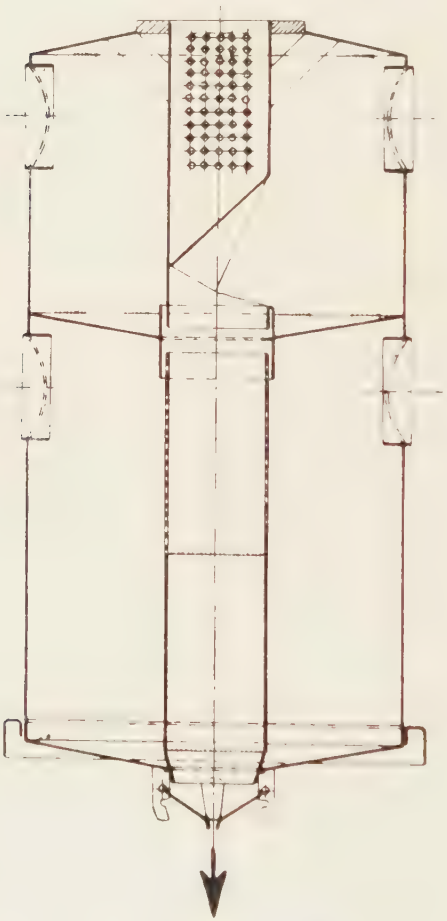

Fig. 11. — Reflection exhaust gases silencer for 230 HP Diesel engine.

2.4. *Interference silencers.*

If a pipe in which noise is set up is divided into two, there is at the point at which they join up again a damping out of the noise when the differences of the ways through the part lengths of the pipe amount to 1/2, 3/2, 5/2... wave lengths, or when the sum of the part sections is 1, 2, 3, 4... wave lengths.

Damping out therefore only occurs in the case of short wave lengths. The effect is considerable when the transversal sections of the branches are equal and these sections are small compared with the wave length.

A positive result will only be obtained when it is only a question of damping out known small frequencies, invariable in time.

Summary.

The separation of the components of noise transmitted through the air and through the solid masses is of particular importance in the case of passenger vehicles, because the problem with which the expert in acoustics is faced is not only to determine the amount of running noise in a coach, but even more to solve a more difficult problem : why is the vehicle noisy or quiet, and by means of what measures and in connection with which transmitting factors is improvement of the insulation against noise transmitted through the air and through the solid masses possible and reasonable ? A study of this kind is given with the aid of the results of trials.

Reducing the noise of the exhausts of combustion motors is necessary both from the point of view of reducing the nuisance caused to the neighbourhood, and the point of view of the inconvenience to the driving staff. Theoretical considerations are compared with different results obtained.

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New W.R. marshalling yard at Margam.

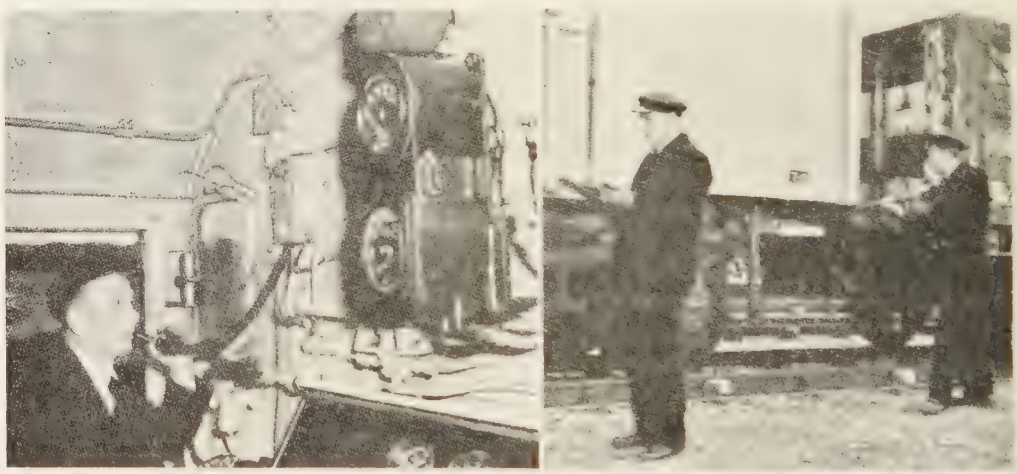
Fully automatic operation.

(*Modern Transport*, April 23, 1960.)

Contribution to modernisation.

Opened on April 11, 1960, by Mr. K.W.C. Grand, member of the British Transport Commission, as already announced in our columns, Margam marshalling yard, near Port Talbot, on the Western Region of British Railways, is a fully automatic yard unequalled in Europe and taking full advantage of the benefits of radar and electronic devices, with radio and punched tape techniques in addition.

Speaking on behalf of Sir Brian Robertson, chairman of the B.T.C., who was unwell that day, Mr. Grand said it was a Welsh occasion but the effects on freight business of the new yard would be felt far beyond the Welsh border. Until that day there were no more modern yards than those of the B.T.C. at Thornton and Temple Mills. Margam had been laid out in conjunction with the Steel Company of Wales, which had its great works at the west end and to which 15 sorting sidings were allocated. The Thornton yard replaced eight smaller yards, Temple Mills 14, and at a saving of £200 000 a year, too. So Margam would make its economies in the Cardiff and Swansea districts and relieve pressure at Severn Tunnel Junction,



Humping engine cab at Margam, showing driver's radiotelephone set, and above, humping speed indicator and ammeter, repeater of lineside hump signal; right, shunter making cuts in reception siding and portable radio being used to transmit cuts to teleprinter operator in control tower.

Pontypool Road and Cardiff. It would handle 4 500 or more wagons and 220 trains daily and would be keyed in to yards at Severn Tunnel Junction, Gloucester Brookthorpe and Shrewsbury Walcot.

General layout.

The marshalling yard is situated between Bridgend and Port Talbot approximately 3 1/2 miles from the latter station, on the down side of the main South Wales lines. It occupies an area of 178 acres extending over a distance of 1 3/4 miles and comprises 33 miles of plain line and 240 fittings. There are 12 reception sidings with engine release line and hump engine return line, together with 50 double-ended sorting sidings, 10 single-ended holding sidings, and 7 single-ended transhipment and cripple sidings with transhipment platform and cattle pens. The capacity of the reception sidings varies from 63 to 95 wagons plus engine and van. The shortest sorting siding holds 43 wagons and the longest 101. All 12 reception sidings are available for down trains, and are accessible over a new junction in the main lines at Water Street underbridge.

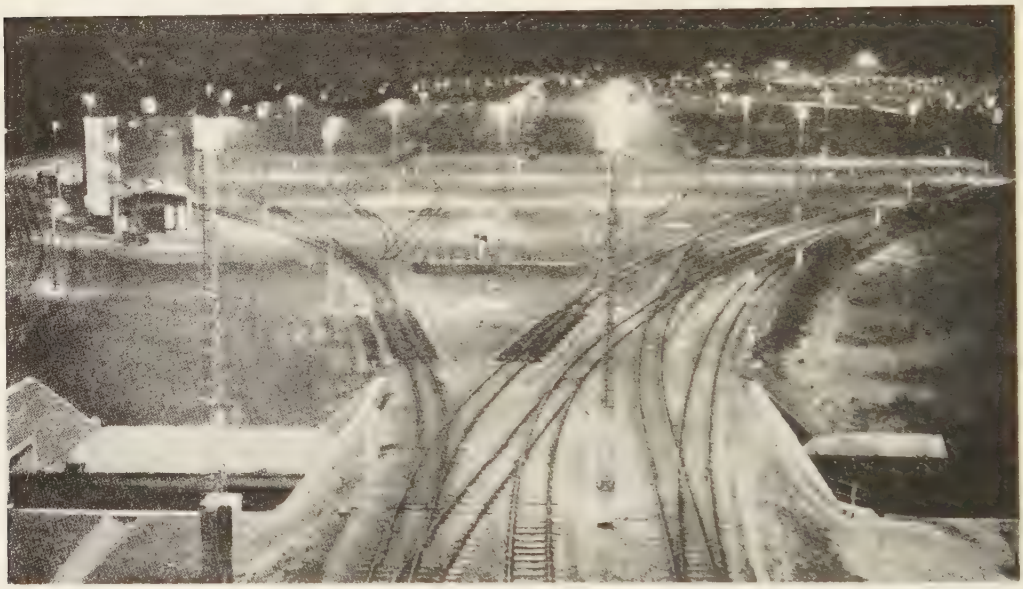
Of the 12 reception sidings five are also available for up trains, and are accessible via a new up arrival line, either from the up goods lines at Margam Moors signal box, or from the Steel Company of Wales sidings by means of two new flyover bridges at the west end of the yard. After sorting, down traffic is cleared from the west end of the yard, but facilities are available for up trains to depart from the two most northerly fans of sidings via a new up departure line leading to the new junction with the main lines at Water Street.

Construction was in six sections: Reception sidings; hump, control tower, and amenities blocks; sorting sidings; down through line, up arrival line and up departure line; Steel Company's access lines; and the doubling of Ogmore Valley Extension line from Margam Abbey Works East to Newlands signal boxes. Before work began the site was a waste of sand dunes known as Margam Moors. The subsoil in the area consists of sand and peat to a considerable depth and the earthwork requirements were

Tape reader which puts in motion the automatic setting of points for each cut of wagons; right, wagon in retarder approaching radar unit in four-foot way.

mostly for fill. By levelling off the existing irregularities and excavating from a nearby borrow pit these were carried out most economically. In all approximately 3/4 million cubic yards of sand were moved by seven Diesel tractors and scrapers. During the peak period of construction as much as 2 000 tons of ballast per day were delivered to the site by specially programmed shuttle services of ballast trains.

dington side of the existing two-track Water Street bridge, necessitating its reconstruction as a four-track bridge. Since the local authority had plans for a future trunk road by-passing Pyle the new bridge was built on a new alignment and the road widened. the local authority contributing to the cost. One abutment has been constructed in the form of a centre pier to allow for future widening.



View from above hump of the floodlit marshalling sidings at night: primary retarders in foreground and control tower at left of picture.

Civil engineering.

The River Kenfig flowed across the site and a diversion was carried out in two straight cuts, one either side of the yard, linked up under the hump area by two reinforced concrete box culverts, under the tracks. Originally the river water was impounded on the upstream side of the yard by a weir. Owing to the diversion this weir had to be replaced by one on the downstream side of the yard. To gain the required length for the yard the turnout fittings were positioned on the Pad

Reception sidings.

The 12 reception sidings converge to a single track over the hump which has a vertical curvature of 11 chains radius. The gradient from the hump falls sharply (1 in 18) towards the sorting sidings, flattening out to 1 in 80 through the two 72 ft. long primary and eight 36 ft. long secondary retarders. All track joints in the yard with the exception of insulated joints have been site-welded by the Thermit or German Quick process.

Out of the 50 sorting sidings 15 have

been allocated to Steel Company of Wales traffic and lines direct to and from its works have been provided in association with the firm. A separate line for outgoing empty wagons from the steelworks to the up arrival line has been provided and two bridges constructed to take this line over the lines from the yard. Lighting of the whole yard is provided by ninety-nine 55-ft. high steel lighting towers each capable of mounting four 1 000 W floodlights and controlled from one console in the control tower, another in the sorting sidings signal-box also individually at the foot of each tower. Lighting is also provided at a lower level where necessary.

Control tower.

The control tower on the down side of the yard is erected on three separate reinforced concrete raft foundations with perimeter beams, each raft separated by an expansion joint to allow for differential settlement. The building itself is also constructed in three parts. The control tower and its main entrance lobby and staircase to first floor, giving access to relay and battery rooms; second floor, air-conditioning plant; and third floor, control room. A lift for access to all floors is incorporated. The compressor room wing is a single storey unit, housing compressors and stand-by generator. The relay room wing has traffic office, workshops, boiler room and other accommodation on the ground floor and the relay room and battery room on the first floor. The superstructure consists of three separate reinforced concrete frames with brickwork cladding except for the rear of the tower where the staircase, which is cantilevered from the reinforced concrete lift shaft, is enclosed by a glass curtain wall secured to a steel framework.

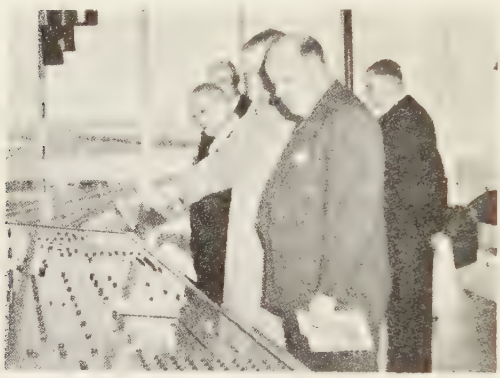
Signalling. Points and retarders.

The main amenity block at the new Margam yard is placed near the hump and contains offices for the yardmaster and his staff and stores accommodation at ground-floor level, and on the first floor a fully equipped kitchen and a messroom. The building has a reinforced concrete framework with brickwork cladding to match the control tower. Provision has been made for a future depot for servicing Diesel locomotives and the formation work has already been carried out. To meet operating requirements the Ogmore Valley Extension Line has been doubled by widening the existing embankment and extending several culverts. A new 110 ft. span bridge on piled foundations with welded girders and prefabricated deck units carrying the new tracks over the main line has been constructed. Road access to the site has been provided at the east end of the yard from the Port Talbot-Porthcawl Road (Water Street) and a new tarmac road links the amenity blocks with the control tower, passing under the hump summit. Marram grass will be planted on a bare dune outside the yard boundaries to prevent wind-blown sand from invading the area of the yard.

Yard operation.

When a train has arrived in the reception sidings, examination by the carriage and wagon examiner is carried out and a shunter walks along the train to divide it into « cuts ». At the same time the shunter uses a lightweight portable radio transmitter to pass information to the traffic office in the control tower concerning the siding destination of each cut and the number of wagons in the cut. In the traffic office, this information is set up on a reperforating teleprinter which causes a perforated paper tape to be produced in code. Simultaneously a copy of the information is produced on three page printers located at the

control panel, in the office of the sorting sidings inspector (at the west end) and the office of the Steel Company of Wales' checker. When a train is about to be humped, the appropriate perforated tape is selected and fed into a tape reader in the traffic office.

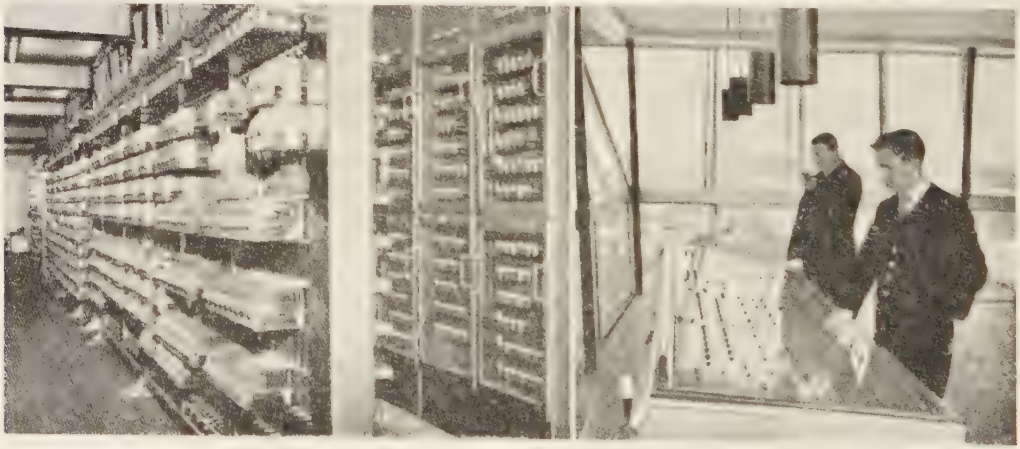


On the occasion of the opening of the Margam yard by Mr. K.W.C. Grand on April 11 : Mr. J.R. Hammond, general manager, Western Region; Mr. R.F. Hanks, chairman, Western Area Board; Lord Brecon of Llanfeigan, Minister of State for Welsh Affairs, and Mr. Grand.

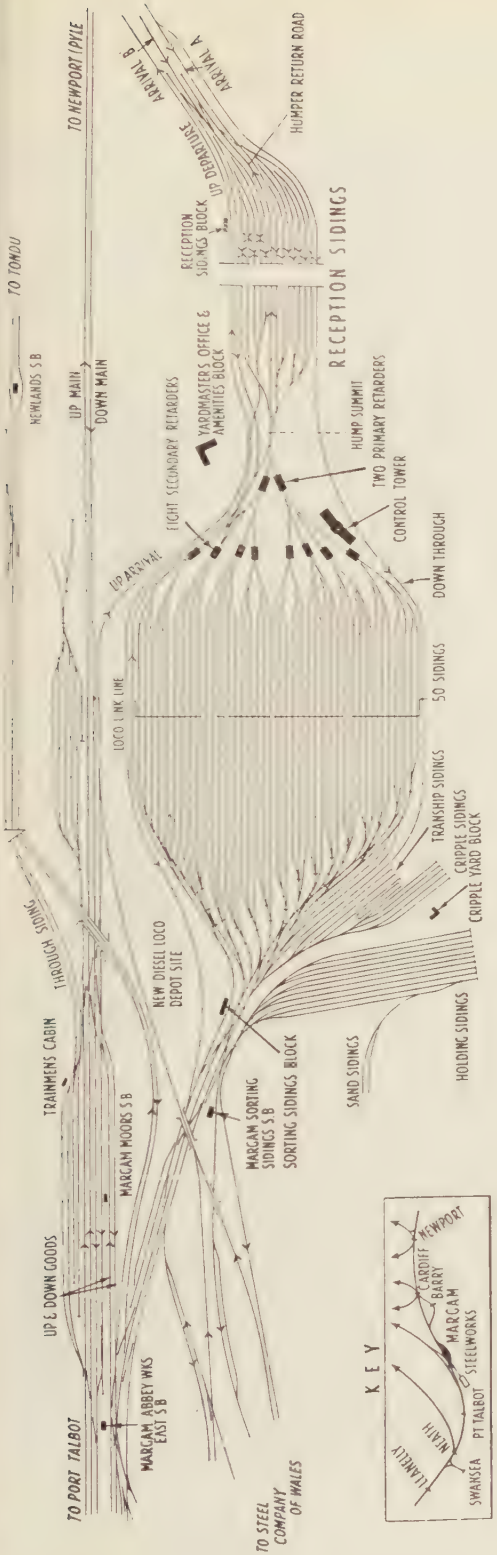
Signalling.

The signalling associated with the reception sidings, the up arrival and up departure lines, and movements at the east end of the sorting sidings, is operated from a control panel of the mosaic type, located in the operating room on the top floor of the control tower. The new junctions in the main lines at the east end are signalled by means of a local relay interlocking, remotely controlled on the « entrance-exit » principle from a mosaic type panel in the signal box at Pyle West. At the west end of the sorting sidings movements are controlled from a new signal box having a mechanical lever frame.

A panel of the mosaic type is also being provided in this signal box to control movements to and from the Margam Abbey sidings, and on the associated goods lines. The arrangements permit the yard to accept and receive traffic in each direction and can thus deal with main-line freight trains from the Cardiff direction and those which avoid Cardiff on the Vale of Neath line. It will receive coal trains from the Tondu area via the Ogmore Valley Extension and also local works and goods depots. A secondary sorting yard is provided to the west of the site for quick exchange of



At the left of this relay room view are 1 200 signalling relays and on the right some of the 2 000 retarder and automatic point setting relays can be seen; right, the control panel.



Layout of Margam marshalling yard at Port Talbot

marshalled groups of wagons between express freight trains which at present call to detach at small yards in the Swansea district. This will give full loads to one or two destinations, save time and mileage and reduce the work in the smaller yards.

The control panel is accommodated on the top floor of the control tower, and is of the mosaic type built up of units 40 mm square containing key switches, push buttons or indicating lamps as required. The right hand portion controls the signalling of the reception sidings and associated tracks on the entrance-exit principle, a key switch being used at each signal position at the entrance to a route, and a push button at the exit, to select the particular route required. On a route being set up, the points are automatically set to the required position, after which the representation of that route on the panel is lit by a line of white lights and the signal is cleared. An indication of the signal aspect is given by a red or green light, only one aperture being used on the panel for either colour. As the train enters the route, track occupancy is indicated by the section of route indication lights being changed from white to red. The points are normally operated from the route setting controls, but emergency switches are provided at the top of the panel whereby they may be thrown individually if desired. Associated with these switches are normal and reverse indication lights, and a red light showing when the points are locked. The usual approach locking and route locking, with time releases where necessary, are incorporated in the controls.

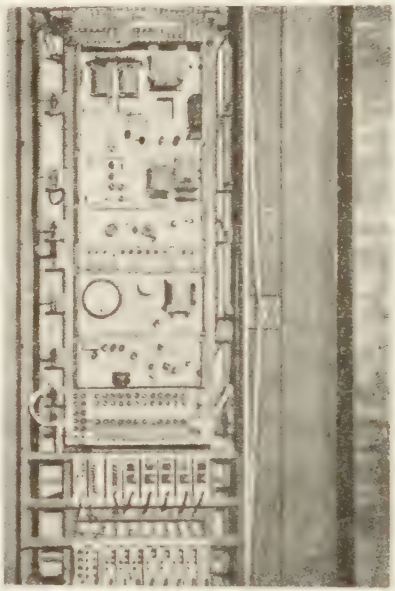
The left hand portion of the panel controls all equipment associated with humping operations. Each retarder is normally under fully automatic control as described later, but switches are provided to give semi-automatic or direct manual control. Each retarder has two switches, one marked A, O, L, M and H, which refer respectively to « automatic », « open », « low pressure », « medium pressure », and « high pressure », the three fixed pressures being used for direct manual control in case of emergency. With the first switch in position A, a second

switch is brought into operation, this being marked C, 1, 2, 3, 4 and 5, giving fully automatic operation at computed speeds, or semi-automatic operation at one of five pre-set release speeds.

Point operation.

The points are normally operated automatically from the route storage associated with each cut as described below, but individual switches are provided to allow for an over-riding manual control when required. The lie of points is indicated on this section of the panel by a white light in the appropriate part of the track representation, and track circuit occupancy is indicated by a red light, one per track circuit. A special switch is also provided on this portion of the panel for the control of the humping signal. Except in the case of some points which conflict with both sections of the panel, all points remain in the position in which they were last used, until called to a different position by the setting up of another route or by the operation of the individual control switch. The points from the hump summit to the sorting sidings and also those in the reception sidings and associated tracks, are operated by electro-pneumatic cylinders working at a pressure of 40 lb. per sq. in., and can be thrown from one position to the other in half a second.

When a train is about to be humped, the appropriate perforated tape will have been fed into the tape reader. On depressing the push button marked « start tape » on the control panel, the tape reader translates the siding destination and number of wagons of the first four cuts into electrical signals which are fed into storage units, with the destinations indicated on the control panel. As the successive cuts pass over the « king » points these indications move up, and the tape reader then translates the information concerning the next cut and transfers it to the vacant storage. Facilities are provided for cancelling or correcting the destination of any of the four cuts displayed. The setting of points for the successive routes is governed by track circuits. A separate track circuit is required for each set of points, and intermediate track circuits between the points are also required. Each track circuit is short enough to reduce to a minimum the space which must be maintained between cuts, but is longer than the maximum wheel base of any wagon that is to use the automatic point setting system.



Electronic equipment for one retarder.

Retarders.

The retarders are operated by electro-pneumatic cylinders working at pressures up to a maximum of 100 lb. per sq. in. They are designed in articulated 12-ft. sections. Each primary retarder is 72 ft. long and is provided with two sets of control valves so that either the first or second half can be operated independently. The secondary retarders are 36 ft. long and have one set of control valves each. Each is supported on a timber cribbage mounted in a well-anchored concrete pit which prevents movement of track due to the large amounts of kinetic energy arrested. In

the case of the secondary retarders, the concrete pits have been made sufficiently large to allow for a possible future lengthening to 48 ft.

The speed at which a wagon should leave the secondary retarder in order to buffer up to wagons already in the siding at less than 4 m.p.h. depends on several factors: the distance to run equals distance to clearance point between sidings plus available standage space in siding; then there must be taken into account the rollability of the wagon and the curvature of the track. The standage distance and the rollability of the wagon vary from cut to cut. The other factors are constant for any particular siding. Apparatus is provided immediately in front of each retarder to measure the rollability of each cut as it approaches. This is done by means of two pairs of wheel detectors of the inductive type, operating at supersonic frequency. The signal from each pair is used to operate a high speed binary counter, giving a count inversely proportional to the speed of the cut. As the distance between the pairs of detectors and the gradient are known, an electronic computer is able to produce a voltage representing the rolling resistance of the cut.

Computer routine.

The output of the computer is transformed into digital code form so that it can be passed forward by a relay network and made available to the release speed computer when the cut is in the retarder. At the same time the rollability computer is made available to compute the rollability of a following cut. A standage store is provided for each siding. This consists of a potentiometer which produces a voltage proportional to the amount of free space left in the siding. The position of the potentiometer is corrected before humping of a train commences by reference to the state of track circuits in the siding. As wagons enter the siding during humping, the potentiometer is stepped by an amount corresponding to the length of each cut. The output voltage is thus reduced as the siding fills up. Pre-set potentiometers are used to produce voltages proportional to clearance distance, curvature, etc., for each.

When a cut enters the retarder a relay operated from the route setting the code for that cut selects the voltages representing distance to run and curvature, etc., for the siding to which it is routed, and applies them, together with the rollability measurement, to the inputs of an electronic computer. The output of the computer is a voltage representing the required exit speed from the retarder. Provision is made on the panel for modifying the computed release speeds slightly in order to cover the effect of a strong adverse or following wind. Radar equipment is provided at each retarder to measure the actual speed of a cut, using the Doppler effect. An ultra-high-frequency signal is radiated in a narrow beam from an aerial in the centre of the track towards oncoming wagons and the reflected portion of the beam is picked up by the same aerial. If the wagon is approaching the aerial the reflected signal is of higher frequency than the transmitted signal, and the difference in frequency is used to provide a voltage representing speed.

Weight detectors.

A greater braking effort is required for a loaded wagon than for a lighter wagon and so that the initial braking effort applied by the retarders can be varied, a weight detector is provided a short distance in front of each primary retarder. This consists of a group of micro-switches mounted in a short length of slotted rail. The information from these detectors is used to control the primary retarders and is then passed to the appropriate secondary retarder along with the destination code used for point setting. As the braking is slightly less effective in wet weather, provision is made on the panel for obtaining a slightly greater initial pressure under such conditions. The voltages representing measured speed (from the radar equipment) and required exit speed, together with the information from the weight detector, are

then fed to the pressure computer. The voltage output of this unit defines the pressure required in the retarder cylinders to remove the excess energy from the cut.

As the difference between the actual speed of the cut and the required exit speed falls the pressure demanded by the computer also falls, becoming zero when the difference is reduced to zero. The output of the pressure computer is fed to the retarder control servo-mechanism, which compares this signal with that from a pressure transducer mounted on the retarder air manifold, and operates the inlet and exhaust air valves so as to maintain the pressure in the cylinders equal to that demanded. Primary retarders are controlled in a similar manner to the secondary retarders, except that distance to run is not involved at this stage, and the exit speed is, therefore, largely dependent upon the rollability of the cut, being designed to ensure that the space between successive cuts is maintained, and that the cuts arrive at the secondary retarder at a speed within the capacity of it to control.

Telecommunications and power needs.

Track circuits in the reception sidings and associated lines of the new Margam marshalling yard are of the standard D.C. pattern with 9-ohm relays of the plug-in type housed in steel apparatus cases alongside the track. Miniature pattern line relays are used in the relay room at the control tower. Track circuits between the hump summit and the fouling point in the sorting sidings are of the D.C. normally de-energised pattern with type A relays housed in the relay room, giving high speed operation. For the setting of the standage store for each siding, A.C. normally de-energised track circuits are employed, as these enable longer sections to be used than would be possible with the D.C. type. A full-wave bridge rectifier with D.C. relay is provided in the relay room and A.C. is fed out to the track circuit through an auto transformer housed in a convenient lineside apparatus case.

Running signals are of the multi-unit short range pattern, and ground shunting signals are of the position light type. Stencil type route indicators are provided where necessary. The humping signal comprises a line of three lunar white lights for each

Main contractors.

Sir Robert McAlpine (South Wales), Limited (main contractor)	Earthworks, permanent way, bridgeworks, drainage, fencing, amenity blocks and signalbox.
John Morgan, Limited	Control tower.
Robert M. Douglas, Limited	Earthworks and permanent way.
British Insulated Callenders Construction Co., Limited	Main electrical contractor.
Lec Beesley and Co., Limited	Internal installations in control tower and yard buildings.
Metropolitan-Vickers — G.R.S. Limited (now Associated Electrical Industries — G.R.S. Limited)	Signalling equipment and retarders.
Pye Telecommunications, Limited	Radio equipment.
Reliance Telephone Co., Limited	Automatic telephone exchange.
British Insulated Callenders Cables, Limited	Signalling cables.

indication. The illumination of three lights horizontally indicates « stop », three lights at an angle of 45° indicates « hump slow » and three lights arranged vertically, « hump normal ».

Cab signalling.

Instead of repeating the humping signal at intervals all along the reception sidings, as has been usual practice, a replica of the humping signal is provided in the cab of each Diesel shunting locomotive employed on humping duties. This is operated by superimposing A.C. of several hundred cycles per sec. over the normal D.C. track circuit, and mounting inductor coils at each corner of the shunting locomotive to detect the current flowing in the rail. The induced current is then amplified on the locomotive and made to operate the humping signal mounted in the driver's cab. Two codes of different frequencies are used; one for « hump normal », and one for « hump slow ». Absence of received code is made to indicate « stop ».

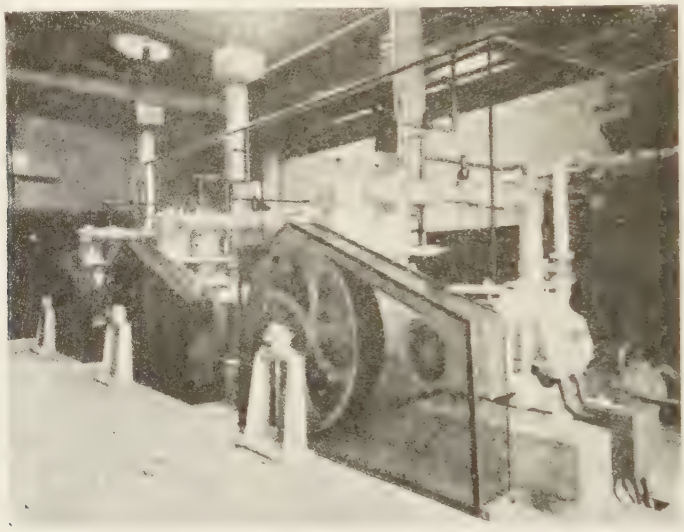
In addition, an audible warning of short duration is sounded upon each change of aspect, thus attracting the driver's immediate attention. When the humping signal is off, the requisite code is superimposed on all track circuits from the hump summit to the far end of the reception siding from which the train is signalled. Absence of code on the other reception sidings would ensure that a second locomotive on an adjacent track could only receive a « stop » indication whilst the first was humping normally.

Sorting sidings at Margam viewed from the hump.

Telecommunications.

Telephone communication within the marshalling yard is provided by a 60-line automatic telephone exchange, giving access to the main railway trunk network through

the switchboard at Port Talbot. In addition to the shunter's lightweight transmitter already mentioned, two-way radio communication is provided between the Diesel shunting locomotives and the panel operators in the control tower, or the sorting sidings inspector at the west end of the yard, on two independent channels. Loudspeaker systems enable the staff in the traffic office or panel operators in the control tower to speak to staff in the reception sidings or the east end of the sorting sidings, and also the signalman at Sorting Sidings signalbox to speak to staff at the west end of the yard layout. Microphones are provided at strategic points in the sidings for return communication from outdoor staff as necessary.



The three Broomwade electrically driven compressors

The compressor plant consists of three electrically-driven compressors each capable of delivering 300 c. ft. of free air per min. at 100 lb.-sq. in. The compressors are automatically controlled by pressure switches, and under normal operating conditions either one or two compressors will run depending on the demand for compressed air. The third compressor is intended as a stand-by machine, but it will also come into use automatically if the air pressure drops to an exceptionally low value. A selector switch is provided to enable the machines in work and on stand-by to be varied in rotation. The compressed air from each compressor is taken through a separate after-cooler and is then fed into two air receivers at the end of the compressor room. Stop valves and by-passes are provided so that any main item of equipment can be taken out of service without interrupting the air supply to the retarders.

A connection is made to the high pressure system to feed through a pressure reducing valve the low pressure system for point operation. This system operates at 40 lb. per sq. in. and a further two receivers for this system are provided at the end of the compressor room.

Electric power.

Mains electricity is supplied at 11 000 V from the Steel Company of Wales to a 600 kVA substation adjacent to the con-

trol tower, and to a 400 kVA substation at the west end of the sorting sidings. The output is the standard three-phase 415-240 V on the four wire system. In the event of a mains power failure a stand-by supply sufficient to enable normal working to continue is automatically made available. The source of power is a Rustom Paxman 8 RPH Diesel engine of 366 b.h.p. which is direct-coupled to a Metropolitan-Vickers three-phase 415-V 250 kVA alternator with exciter. The output of the alternator is controlled by a switchboard which also embodies the control gear for automatically starting the engine upon power failure. The automatic control is arranged to change over to the stand-by supply if the mains voltage drops by more than 10 %. When this happens an audible alarm sounds at the control panel, and this can be stopped by turning a switch to the « stand-by » position. The change back to mains supply when this again becomes available is done manually, and the two supplies can be synchronised momentarily to avoid interrupting the supply during this operation.

The total electrical loading represented by the lighting installation of the yard and its grounds is approximately 300 kW and included in this figure are 216 by 100-W Duoflux lighting fittings which are used to floodlight the working areas of the yard proper. These flood-lighting fittings are mounted at 55 ft. above ground level on 99 tubular steel towers and are of two types. These are 63 towers having triangular bases 2 ft. 6 in. per side, for use in positions where sufficient clearance is available, and 36 towers having 1 ft. 6 in. square bases where space between tracks is severely restricted. The square towers were specially designed for the Margam marshalling yard, as were the top platforms for all the towers. These platforms are provided with vertical tubes on which are mounted the lighting fittings, and by the removal of a taper pin, can be rotated, thereby enabling the lighting fittings to be swung round over the platform and so facilitate cleaning and lamp replacement.

The steel floodlighting towers are finished galvanised with two coats of aluminium paint, special regard to the finish having been paid in view of the prevailing site conditions of strong sand laden winds, and the possibility of rapid erosion of paint work. Each tower is mounted on a 6 ft. cube concrete base designed to suit the load bearing characteristics of the Margam sand. In addition to the steel towers there are approximately 100 standards for the lighting of the various access roadways and secondary parts of the yards. The main yard lighting is controlled from two consoles of the type used for aerodrome runway lighting, and each has a diagrammatic representation of the layout of the lighting points it controls, together with miniature lights to indicate the correct working of the circuits controlled, including those which would be fed by the standby set in the case of the failure of the mains supply.

The whole scheme, which is part of the British Railways modernisation plan, has been developed and directed by Mr. M.G.R. Smith, chief civil engineer, Western Region; Mr. A.W. Woodbridge, formerly signal engineer, W.R., and now chief signal engineer, B.T.C., and Mr. A.A.A. Cardani, who succeeded Mr. Woodbridge.

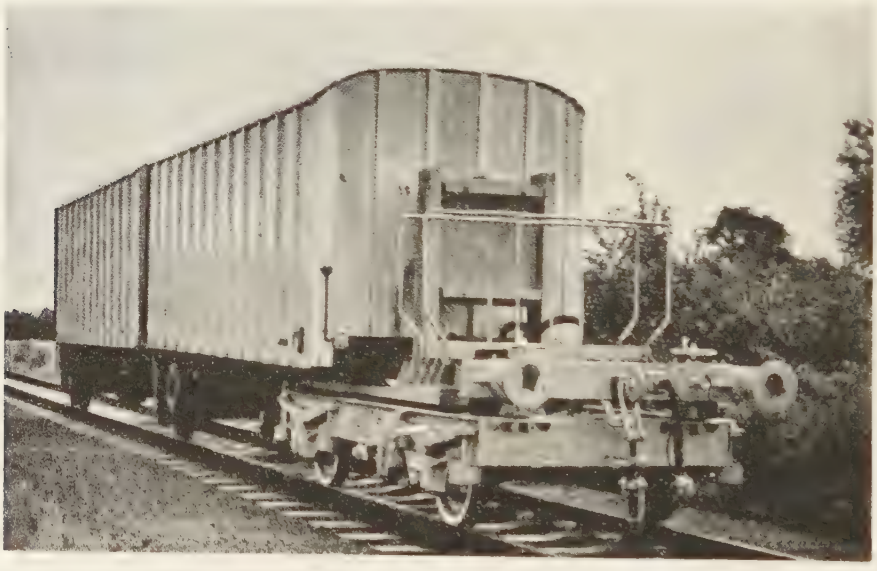
[656 .225 (42)]

Combined rail-and-road vehicles for British Railways.

Semi-trailers, each with tubular-steel backbone and twin wheel sets, to form articulated train for the efficient handling of door-to-door traffic.

(*The Railway Gazette*, September 9, 1960.)

After an extended period of development testing a combined road and freight vehicle, the Roadrailer, is being demonstrated to railway managements, road transport operators, and transport users. It was built by the Pressed Steel Co. Ltd. at Linwood works, Paisley.



Prototype Roadrailer vehicles coupled to leading adapter bogie on which superstructure can be rotated to suit direction of travel.

The basic idea was conceived indedendently by both British Railways, Eastern Region, and the Chesapeake & Ohio Railway Company from which a licence was obtained by the Pressed Steel Co. Ltd. This company was appointed as development contractor by British Railways to enable the required design modifications and construction to proceed, in co-operation also with British Road Services, to meet both road and rail conditions obtaining in this country.

Improved door-to-door service.

The Roadrailer is intended to combine the flexibility and convenience of road

transport in its collection and delivery functions, with the speed and economy of railways for the trunk haul. Although the load/tare ratio does not greatly exceed 2 : 1, the total equipment cost per payload-ton is less than either road or rail transport. This has been possible because the Roadrailer is basically a road-vehicle semi-trailer with the minimum of extra equipment to enable it to run on railways, rather than a modified railway vehicle.

Two sets of wheels, mounted on a rocking beam at each side, are fitted in tandem. Torsion springing is incorporated in the cross-shaft connecting the beams.

A maximum of 75 Roadrailers may be coupled to form a train, or they may be attached to the rear of other railway vehicles. Because it is a two-wheel vehicle, and special couplings are used, an adapter bogie is necessary for coupling the Roadrailer to railway vehicles. When Roadrailers are coupled together, the rear axle of the leading vehicle supports one third of the weight of the trailing vehicle.

Goods are collected from consignors in a Roadrailer hauled by a conventional road tractor vehicle and taken to the nearest rail terminal provided with transfer facilities. The transfer requirements are a supply of compressed aid and a section of track with the ground built up to rail level.

The Roadrailer is driven into position over the track and the rail wheel-set and landing legs lowered. Coupling to the rear of another Roadrailer or to the adapter bogie is automatic on impact.

Transit is then by fast trunk rail service to the nearest or most suitable destination terminal, where the transfer from rail to road operation takes place. Conventional marshalling is eliminated as single vehicles can be withdrawn from, or inserted into, any part of the Roadrailer train.

Alternative bodies.

On the two prototype vehicles the bodies are of the end-loading container type with a pay-load capacity of 11 tons. Designs are in hand for a range of body types, including tank wagons, tippers, motorcar-body trailers, and flat wagons.

Leading particulars of the prototype vehicles are as follows :

Gauge	4 ft. 8 1/2 in.
Gross weight	16 tons
Payload	11 tons
Volume of loading	1 400 cu. ft.
Maximum speed	70 m.p.h.
Minimum curve negotiable.	2 1/2 ch.
Length over body	24 ft. 7 1/2 in.
Overall length	26 ft. 11 1/4 in.
Width	8 ft. 0 in.
Height inside container	8 ft. 2 in.
Braking on rail	Vacuum, three stage
Braking on road	Compressed air

Each of the wheel sets can be lowered as required for running on road or rail. The rocking beams, one at each side, are attached to a Torsilastic cross-shaft, which is pivoted by a centrally mounted forked lever. Movement of the lever is by a motor-driven screw pulling or pushing on a nut anchored in the fork end.

Jacking mechanism.

The jacking mechanism is a Rotax actuator. It consists of a reversible air motor driving a case-hardened steel screw. The running nut anchored in the forked lever is of the high-efficiency recirculating-ball type. The screw is silverplated to prevent corrosion. A special form of overrun stop is fitted at each end of the screw to prevent damage from overload. The air motor, mounted at right angles to the actuator screw, is of the sliding-vane type, fitted with an automatic brake and an overspeed regulator. Air at 80 lb. per sq. in. is admitted to the motor by a hand-controlled poppet valve.

Friction brake.

At the output shaft end of the motor is a spring-loaded friction brake. The brake pressure is released by a piston when air

pressure is admitted to the motor. When the air pressure is cut off, the motor is stopped instantly by the brake. The brake is also used to check the lowering speed during the first part of a transfer movement.

Maximum speed of the motor is limited to 5 500 r.p.m. by a fly-weight governor, arranged to restrict the air inlet orifice. The eccentric rotor housing is provided with two sets of inlet and exhaust ports. Movement of the housing changes the direction of the motor.

From the rotor the drive is taken through a quill shaft to a bevel gear unit. The latter incorporates an epicyclic reduction gear, the planets of which engage with a gear on the operating screw. The bevel gear provides a 5.85 : 1 reduction and the epicyclic gear a 3.54 : 1 reduction. A locking device prevents rotation of the screw when either the road or rail wheels are in the running position.

Rocking beam.

The rocking beam on which the wheelsets are mounted is carried on a rubber torsion-spring assembly. The rubber is bonded to an inner and outer steel tube. The outer tube is attached to the beam and the inner to the forked lever which is positioned by the actuator.

With a travel of 18 in., the actuator rotates the torsion-spring assembly through an arc of 70 deg., and the load is then carried through the torsion spring to the wheels. In the event of ageing or permanent set of the rubber occurring after a long period of use, the spring deflection would increase. This is readily counteracted and the correct floor height maintained by using the over-travel provided in the actuator.

Spring damping is by two direct acting hydraulic shock absorbers anchored to brackets on the torsion tube assembly and

Roadrailer in use as semi-trailer with rail wheels retracted and showing female half of coupling and road lighting equipment.

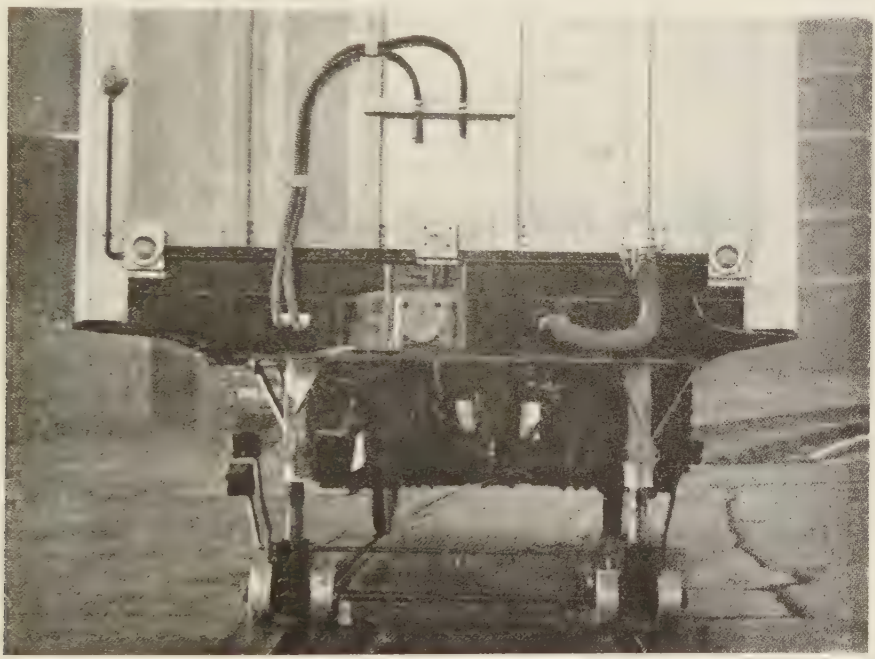
to the body cross-members. The lengths of the rocking beam arms carrying the rail and road wheels are proportioned to provide an approximately equal static deflection and actuator loading.

Rail wheel-set.

The rail wheel-set of conventional form is carried in Timken taper-roller-bearing axleboxes, suspended by ball-and-socket-jointed swing links in a jaw of the rocking beam. This anchorage permits, between the limit stops, a fore-and-aft movement of 1 in. and a lateral movement of 3 in.

The rocking beam carrying the twin road wheels at each side is provided with a hinged joint which permits the road wheels, when retracted, to be isolated from the rail wheels. In the retracted position the wheel assembly is held firmly by a coil spring against the underside of the body. This eliminates the adverse effect of high frequency rail joint vibration on the road wheel bearings, and maintains the running clearance required between the road wheels and the rail.

The brakes fitted for railway operation are the Girling railway disc type, in which braking surfaces incorporated in the wheel webs are gripped between a pair of brake pads. Each wheel has an independent set of brake gear operated by its own vacuum cylinder. Manually-operated braking is provided for one wheel.



Leading end of vehicle showing male coupling, vacuum hose, electrical connections, and landing wheels fully extended.

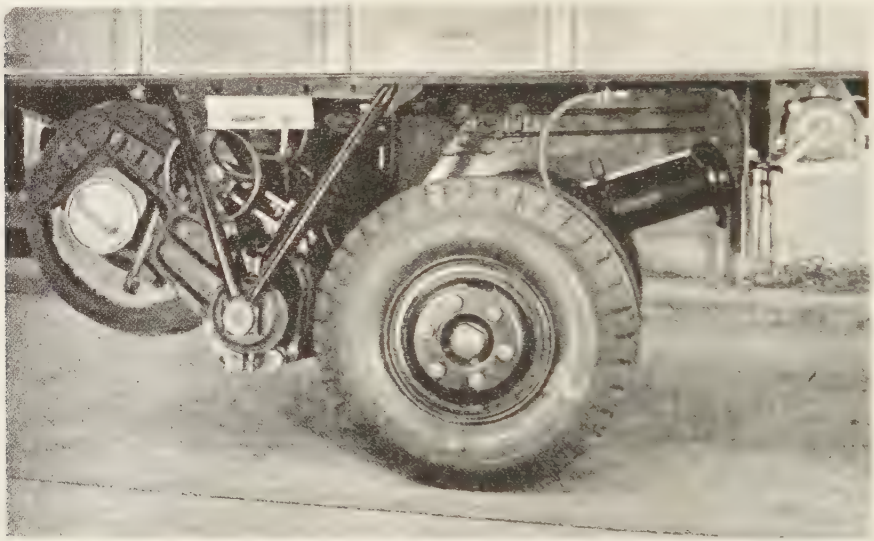
Three stages of braking.

To cover variations in axle loading between tare, half laden, and fully laden

conditions, three stages of braking are provided. For tare weight braking the right-hand side brake, powered by an 8-in. dia. vacuum cylinder, is used, giving a deceleration rate up to 2.04 m.p.h./sec. Braking for a half-laden vehicle is by a 10 in. dia. vacuum cylinder operating the left-hand side brake. This also gives a maximum deceleration rate of 2.04 m.p.h./sec. Both cylinders are used for the braking of a fully-laden vehicle, giving a deceleration rate up to 1.58 m.p.h./sec. as a maximum.

A weight indicator is attached to the end of the Torsilastic suspension spring and the three-position rotary selector valve on the underframe is set to give the correct braking in accordance with the reading shown. An important detail is that when a Roadrailer is coupled as the rear vehicle of a train the axle-road is insufficient for braking. Therefore, a fourth position is provided on the brake selector to allow the brakes on this vehicle to be isolated.

The brake cylinders are of the diaphragm type, which eliminates the use of vacuum seals. Operation is through a sliding compact lever system incorporating an automatic slack adjuster to compensate for pad wear. A step is machined on the brake pads to indicate the permissible wear limit. The pads are in a non-metallic friction material and the brake shoes are readily removable for servicing replacements. Brake reaction is transmitted through rubber bushed links to the underframe. The hand-brake is applied by handwheel operation of a screw thread, and the brake capacity is such that the vehicle can be held on a 1 in 37 gradient by an effort of 67 lb. on the handwheel.



Vehicle running gear at off side showing rocking beam and suspension details, also actuating control levers.

Braking of road wheels.

Braking of the road wheels is by Girling two-leading-shoe brakes of the heavy road vehicle expanding type. The brake shoes are 12 1/4 in. in dia. and 5 in. wide. They are mounted in pairs and operated by a compressed air cylinder. Roller tappets, with a readily accessible adjustment for

lining wear, are operated by the normal wedge-type expander. The two-leading-shoe design provides a balanced servo action giving equal braking in both forward and reverse.

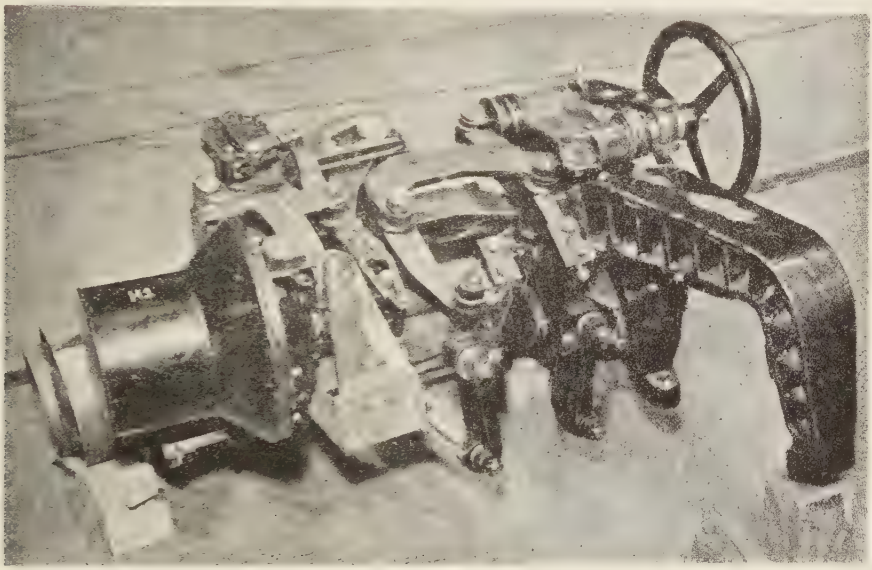
The air reservoir on the underframe is charged by a compressor mounted on the engine of the tractor vehicle. A relay valve is connected in the pipe-line between the air reservoir and the brake cylinders. This reduces the amount of air to be handled by the driver's control valve and also provides a means of making an emergency brake application in the event of a vehicle breaking away.

The main member of the underframe is a seamless-steel centre tube 5 1/2 in. in dia. and 0.36 in. thick. This centre sill, which carries all the buffing and draw loads, is threated into the rear coupler as its only means of attachment to the vehicle. The coupling and centre sill have been designed to withstand 400 000-lb. buffing load and 250 000-lb. pull without overstressing the material.

The body is supported on the centre sill through Cor-Ten steel cross-members, located at 24-in. centres and free to slide on the centre sill through nylon bushes. The cross-members transfer the load to the bodysides and provide column stability for the sill. With 12 deg. angular movement the coupler is of the plug and socket type, and is capable of supporting vertical and also draught loadings.

The ball joint plug portion is screwed and welded into the centre sill tube and the socket is a steel casting welded into the rear headstock. Engagement is automatic on impact and four retractable pins lock the plug in the socket. The pins are operated by a hand lever at the side of the vehicle.

A breakaway safety device has been



Girling disc-brake assembly and rocking beam dismounted to show eight-inch vacuum cylinder and compensated linkage.

developed which is designed to apply the brakes and support the trailing vehicle in the event of a coupling failure.

When the Roadrailer is separated from the towing vehicle the towing end of the unit is supported on two 16-ton jacks. These are of the conventional trailer pivoted type, with the addition of a hinged extension at the lower end.

Hinged extensions.

There is a variation of up to 14 in. between the height of the coupling connections of the road and rail vehicles and the hinged extension saves time by taking up the bulk of this difference without cranking the jack handle. The jacks are inter-connected for operation from the right-hand side of the vehicle.

The hinged road-extensions, which are counterbalanced, are fitted with aluminium landing wheels to permit limited movement of the road vehicle. On the rail foot of the jack, side plates are fitted which register with the railhead to position the vehicle laterally. The single axle suspension of the Roadrailer necessitates a support for the coupling end when coupled behind a locomotive or standard railway vehicle.

A four-wheel adapter vehicle consisting of bogie and superstructure is provided for the purpose mentioned above. The bogie is of a conventional type with roller-bearing axle-boxes, semi-elliptic springs, and a manually-operated brake system.

Fitted at one end of the superstructure is a pair of standard buffers and screw link drawgear and over the centre of the bogie is a Roadrailer coupling socket. This position gives a balanced wheel loading on the bogie. The superstructure is mounted on a central pivot to enable it to be swung into position as required without using a turntable.

The coupling socket is provided with a ring spring draw gear to absorb the normal locomotive or train impacts. Above the coupling socket is mounted a counterbalance which brings the mass centre of the vehicle into the same vertical plane as the socket.

Compressed-air for transfer motor.

When operating at maximum output the actuator air motor consumes 120 cu. ft. per min., at 80 lb. per sq. in. This will be supplied at terminal points by a mobile compressor set. A self-propelled unit which has been designed for this application is a two-stage compressor powered by a two cylinder air-cooled Diesel engine. Air is stored in a receiver at 400 lb. per sq. in. and supplied to the vehicle at 100 lb. per sq. in. through a reducing valve. The truck is driven by a series-wound electric motor, supplied by current from a generator driven by the engine.

At terminals where many of the Roadrailers were to be dealt with a yard tractor would be used for road/rail transfers to speed up clearance of the road vehicles: in which case the compressor set would be mounted on the tractor.

An illustrated description of the original prototype Railvan of the C. & O. Railway was given in our April 26, 1957, issue. Under the licensing agreement, the Pressed Steel Co. Ltd. is free to supply Roadrailer vehicles to private transport operators, and to railways overseas, except in America.

Principal sub-contractors include :

Actuator	Rotax Limited
Brakes and dampers	Girling Limited
Lighting	J. Lucas Limited
Landing legs . .	Davies Magnet Works Ltd.
Tyres, springs and wheel discs.	Dunlop Rubber Co. Ltd.
Tyres .	Avon India Rubber Co. Ltd. Goodyear Tyre & Rubber Co. Ltd.
Brakedrums and hubs	Alport & Alder Limited
Railway wheels .	Owen & Dyson Limited
Vacuum-brake cylinders	Cresham & Craven Limited
Extrusions	High Duty Alloys Limited
Castings	George Blair & Co. Limited
Roller bearings .	British Timken, Division of the Timken Roller Bearing Company
Actuator bearings	Glacier Metal Co. Limited

[656 .22 (73)]

New goals for RR research,

by A. S. Lang,

Assistant Professor of Transportation Engineering Massachusetts Institute of Technology.

(*Railway Age*, August 22, 1960.)

Are railroads lagging behind their competitors in efforts to improve and exploit their technological advantages? Professor Lang thinks they may be, and in the following article he cites automatic train operation and « rationalizing the railway freight vehicle » as two cases in point.

The views expressed below are the author's own, of course. Railroaders are sure to find the ideas challenging, whether they agree with them or not.

A former D. & R.G.W. officer, Mr. Lang has been at M.I.T. since 1956. He instructed at the Army's transport school, Ft. Eustis, Va., in 1952-55.

If the technology of modern transportation is examined in detail and the principal characteristics of each mode outlined, it is possible to identify those elements which render a transport system both serviceable and economical.

Rail transport stands up well in such a comparison. Such an inquiry suggests, in fact, that railroads are very nearly the technological ideal for general-purpose freight transportation.

Among the major factors working in favor of rail transport are these : high capacity per unit of plant investment; capability to accept a wide range of cargoes; extremely low energy and manpower requirements, and minimum problems of movement control.

Such factors, working, so to speak, for the railroads, help explain why these carriers are still able to command close to half of the total inland freight transportation market — in spite of an outmoded rate structure, outmoded labor contracts, outmoded regulation.

In the light of such an analysis it is a matter of much concern that railroads are not moving ahead at a faster rate to exploit their technological advantages. Some progress is being made, but nothing which measures up to the potential. As an example, the possibilities for a further increase in the speed and reliability of service are tremendous. The possibilities for practically complete flexibility of origin and destination by means of rail-truck coordination are increasingly apparent. The possible reductions in line-haul and yard operating costs through improved technology are truly exciting.

Railroad transportation will not, however, realize its potential in these and other areas without difficulty. Time is short, moreover, because competing forms of transportation are pushing their own technology at a rapid rate.

Specifically, railroads must struggle to overcome two major obstacles :

— the first of these is the technological inertia inherent in the industry because of its very size and because the need for industry-wide standardization results in a long lead time for innovation;

— second, and perhaps more important, many of the innovations which will produce the technological revolution in railroading are sufficiently unlike our present technology so that we cannot depend upon them to evolve simply as a matter of course.

If the industry is to realize its technological potential, then, it seems that at least two things must be done. First an

early start must be made on researching those developments which appear likely to become technologically and economically feasible within the next few years, so as to insure against serious delay in their being put into use. Second, long range research studies aimed at the evaluation of major innovations and more specifically at the development of more complete systems of facilities and techniques should become a major part of the industry's regular activities.

Study more than hardware.

An excellent example of the sort of large-scale, long-range technological innovation which the railroad transport industry must soon undertake is the problem of developing automatic train operations. As many have correctly pointed out, railroad transport is particularly susceptible to such operation. In the face of an inexorable advance in wage rates — a condition towards which our whole economy is striving — it is, in fact, no longer a question of *whether* we shall have automatic train operation, but merely a question of *when* we shall have it.

There has been some research on the technical details of this problem, but there has been almost nothing which one could call planning. One of the essential points which seems to have been overlooked is that there is much more to the problem than the mere development of control equipment for locomotive and wayside installation. Automatic train operation will affect the economics and the technology of literally the entire railway industry. It is these broader implications which are in the long run far more important than the question of what sort of hardware one needs to do this job. While we must do further research on hardware, the fact of the matter is that the bulk of this has long since been done by the railway supply industry. The real research job here is an inquiry first into the economics of such operation, second into the impact of such operation on the product of the entire railway plant, and third into the non-technical effects (such as displacement of personnel) of such an innovation.

« Systems » approach needed.

Inasmuch as the potential savings to the North American railway industry run well into the hundreds of millions of dollars annually, it would seem that automatic train operation is a matter with which the railroads should be extremely concerned. Yet the industry has for practical purposes ignored the question altogether. One should note further that expecting the equipment suppliers to do more than a small part of the thinking on a « systems » problem so broad as this is quite unrealistic. As J. J. Wright of the New York Central pointed out in a recent Railway Age interview, « Rail suppliers naturally tend to be oriented toward individual products. By and large they don't do system research. »

The problem is certainly one which in its ultimate form must be researched by the railroads themselves. The amounts of money required for such research are, moreover, so large that one cannot expect any individual railroad to do the job alone. The need is for an industry-wide attack, and one which will begin in the near future if the day of operative systems is not to be postponed longer than railroads can wait.

Another major systems problem, and one which fits into the category of the sort of long-range thinking that the industry needs to do, is the problem of rationalizing the railway freight vehicle. The two million freight cars with which the industry operates are even today a technological anachronism. In a very few more years as train speeds increase, reliability becomes more essential, and labor costs continue to rise, these cars will surely be hopelessly out of date.

Certainly everyone can agree that most of today's cars are designed for the competitive conditions of 1920 or thereabouts. Special service equipment built within recent years has only partially remedied this condition. The most important aspect of

this problem is the effect which the mechanical characteristics of these cars have on the performance capabilities of the railroad system as a whole. Here we find that the basic railway car is perhaps the most serious single obstacle to the realization of the full technological potential of railroad transport.

The present freight car is inefficient because of its high dead weight. It is unreliable, because it was designed for a much less demanding sort of service. It is expensive to operate, because of an outmoded system of brake control and a labor-consuming (though workable) coupling system. Its service capabilities are poor, because of an almost total lack until recently of any consideration for the larger physical process of which the line-haul is only a small and relatively inexpensive part.

Producing a rational railway freight vehicle seems clearly to involve starting from the steel wheels and working up. Nothing above the wheels can or should be considered sacred. This again is a job of considerable proportions. Clearly it is too large for an individual railroad to undertake and impossible for an individual railroad to implement. Again, a programmed systems research effort is an absolute necessity. Again, because of the exceptionally long lead time involved in designing and building a fleet of new cars, this is a job whose inception the industry can scarcely afford to put off another day.

The two problems above, though somewhat dramatic, are by no means unusual. The railroad industry is faced with many problems of the same general nature. Among these are the problem of developing a more rational technique for distributing cars on both an intra and inter-railroad basis, the problem of developing more rational techniques of classifying cargo both on the car and off, and the problem of developing a truly efficient car reporting and accounting system.

All of these problems have a number of things in common. The first of these is that each has very extensive and profound implications for the operation and financial condition of the entire railway industry. Second, a *complete* study of any one of these problems could by itself cost more than the railroads are now spending for *all* types of research each year. Third, the study of such problems would require a very wide range of specialized talent, a good deal of which is not now presently available in the industry in any form, let alone in quantity.

In short, these problems require a type of study with which the railroad industry has very little familiarity and towards which they have, in the past at least, had almost no inclination. These are « systems » problems, and ones which require what is often called « program » research.

It is obvious, in any case, that this sort of study cannot in general be reasonably undertaken by an individual railroad. Not only do the ultimate advantages of such studies accrue to the entire industry rather than to individual railroads, but the costs and responsibilities are also greater than any one company can be expected to bear. If work of this sort is to be done, it can only be done under the auspices of several large railroads, or better yet, by the industry as a whole.

An important additional reason for undertaking such work on an industry-wide basis is that the subsequent implementation of new techniques and modes of operation would be greatly simplified if everyone had a personal stake in its outcome.

Each road can help.

Undertaking the study of such problems would not, however, obviate the need for an accelerated program of research on more detailed problems. This means quite simply, that there is no conflict between research studies of the sort suggested here and the research aspirations of individual railroads. Research programs on individual railroads would, in fact, be a necessary supplement to these larger projects.

Perhaps the most compelling thing about these problems is that the industry must necessarily face them at some time in the not-too-distant future. As suggested above,

there is no question of *if*, but only a question of *when*. There is, moreover, no question but that if these problems are handled on a fragmentary and uncoordinated basis by a few railroads they will not be handled so well as if they were subjected to a planned program of coordinated research.

One cannot escape the conviction that this is the very sort of planning which the railroad industry individually and collectively has failed to push or even to recognize in the past. One needs only to look at those of the large industries which are currently enjoying the greatest measure of financial success to realize that long-range technological planning has become an essential ingredient of industrial progress in recent years.

One could reasonably ask whether there will be any railroad industry in North America 20 or 30 years hence if it continues to ignore this more farsighted type of planning. The very short range sort of capital improvement programs which railroads currently label as their planning effort certainly falls far short of the mark.

[656 .25 (494)]

Transportable signalbox on Swiss Federal Railways.

Temporary points with relevant signals and transportable signalbox facilitate single-line operation during engineering work.

(*The Railway Gazette*, January 15, 1960.)

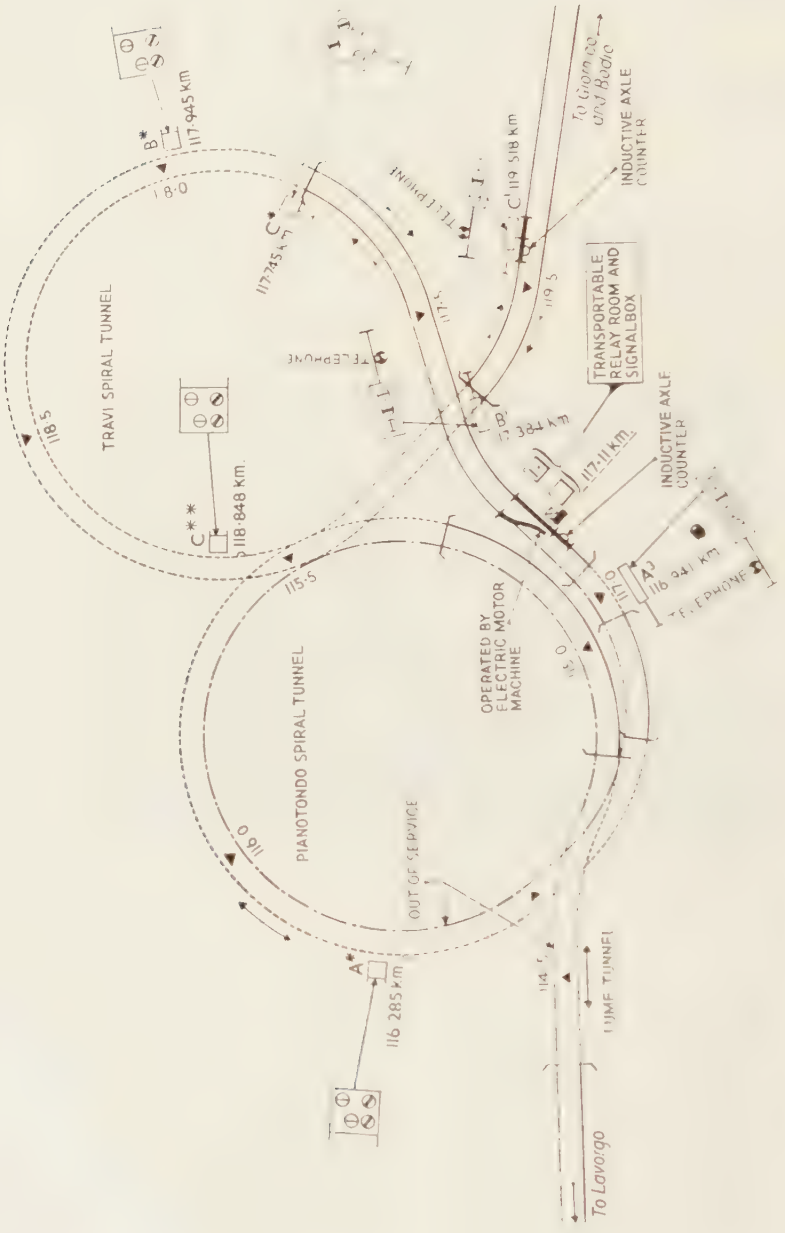
To effect engineering work with the least possible interference with traffic always has presented problems, especially when trains cannot conveniently be diverted over alternative routes. Single-line working can of course always be resorted to, but special equipment is essential if delays are to be kept to a minimum. An example is the transportable signalbox and associated equipment used by the Swiss Federal Railways and shown in the accompanying illustrations, which refer to an application in 1958 on the Gotthard line.

Signalbox and relay room in position on special frame supports alongside track.

This line carries more than one-third of the goods and about one-fifth of the passenger traffic of the whole S.F.R. system. Train intervals are very short and afford no opportunity of carrying out permanent way, bridge, or overhead wire maintenance or renewals without considerable disturbance to traffic, especially where station distances are appreciable, as between Giubasco and Rivera-Bironico, about 7 miles, and Lavorgo and Bodio, 8 miles.

Halving the section.

The Engineering Department, in consultation with the traffic officers, therefore proposed installation of an intermediate set of points about midway in the section, on the principle adopted in 1947 for the



Layout between Pianotondo and Travi Tunnels on Gotthard line, controlled by transportable signalbox.

9-mile Gotthard Tunnel itself, as described in *The Railway Gazette* of February 6, 1948. In the latter case, however, permanent double crossovers were provided, remotely controlled from Göschenen Station.

Such points would enable half the section to be worked as a single line, liberating one track completely for the engineers; the other half would remain double as before. With a little rearrangement of the timetable the bottle-neck so created could be tolerated, provided full signalling was maintained, including the interlocking block.

The location of the points would need to be carefully determined from both the operating and topographical points of view. In mountainous country they would almost certainly have to be on a gradient, and so increase the difficulty of starting a train stopped by signal, and especially if there were curves at or near the points. When the single line is on the up gradient side, such stops can hardly be avoided; but they can be rendered less frequent in proportion to the rapidity with which descending trains can vacate the section.

To facilitate this, a starting signal is provided, controlled from the temporary signalbox at the points and located at least 900 yd. beyond the end of the single-line section. A train can thus draw forward to the intermediate signal before the preceding one has cleared the ordinary block section in advance. Axle-counting is used to prove this supplementary section unoccupied before another train is allowed to enter it.

Signalbox unit being conveyed to train by lifting truck.

Temporary equipment.

The diagram shows the layout adopted in the case of the temporary signalbox installed between the Pianotondo and Travi spiral tunnels, on the southern approach to the Gotthard Tunnel, to free one track between this point and Lavorgo Station for engineering work. The home signals, A and B, near the points give the standard indications adopted by the Swiss Federal Railways for the movements involved and are provided with distant signals, as is also the starting signal C on the double line. As this distant signal is located in the Travi Tunnel it is repeated by an outer distant at the northern portal. Telephones are provided at the stop signals. The points are operated by an electric motor machine and are of large radius to permit a speed of 37 m.p.h. on the diverging route.

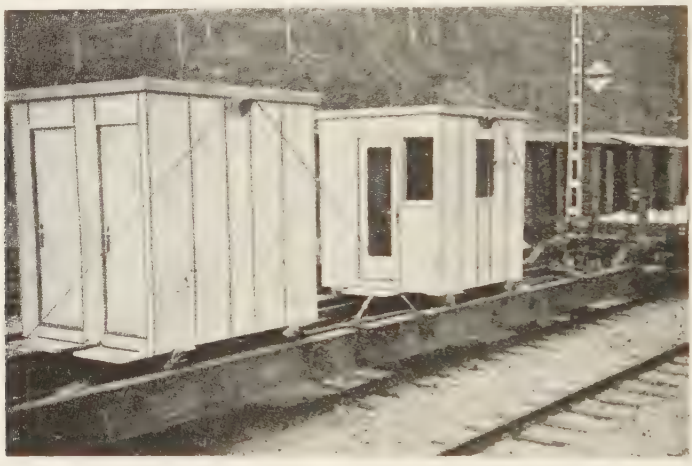
Temporary alterations at Lavorgo Station are necessary to allow of movements being made to and from the single line under full signal protection.

Three other variations of this arrangement are possible, according to which particular section — to the left or right — has to be rendered temporarily single and which of its two tracks must be put out of use. The apparatus, therefore, was specially designed by the suppliers, Integra A.G., of Wallisellen, Zurich, to be readily adapted to any of the four possible layouts.

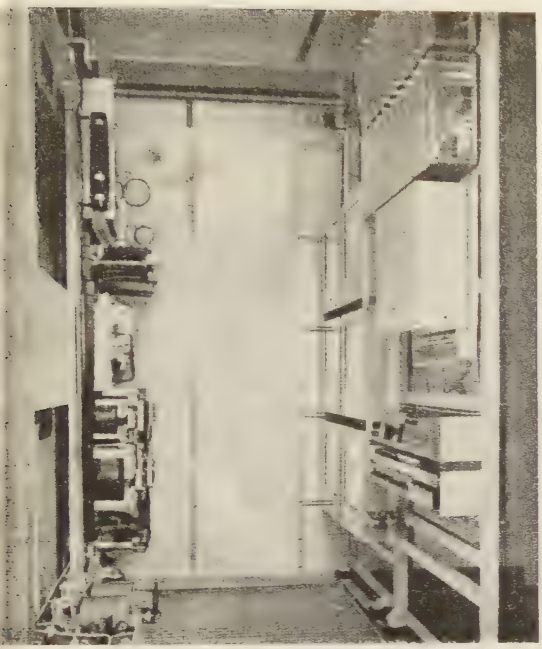
The signalbox has a « domino » type push-button panel and a simple rearrangement of the components and cover plates, quickly effected, enables it to suit the particular layout required in each case. As the interlocking block must necessarily be able to work with whatever types of signalbox happen to be in use at the adjoining stations, A.C. apparatus, operated by magneto hand generator, is provided, as this is readily combined with other forms of equipment. There are communication with the main telephone circuits and means of operating the station-to-station signal gongs, distinctive of train operation in Switzerland. Power is taken normally from the 16 2/3-cycles traction supply, with facility for automatic changeover in case of failure to the public supply, where such exists.

Constructional features.

Little time is usually available for installing the temporary points, modifying the overhead wiring, placing the signalbox and relay room in position, and connecting up to the outdoor equipment. Special attention therefore was given to the design of every item. To keep size and weight within acceptable limits the signalbox proper and relay and transformer room were made as similar units of plywood, faced with thin aluminium sheeting, on welded tubular steel frames. Each weighs in working order about 1 3/4 t. Rollers enable them to move easily in runways, and they are carried to site on a drop-girder transporter wagon, from which they can be transferred to special supports, also fitted with runways, placed in readiness alongside the line. It is also possible to move the units by lifting trucks. When they are in position, connection between them and the lineside equipment is effected over multi-core corro-



Relay room and signalbox on way to site on drop-girder wagon.



Interior view of the transportable relay room.

sion proof cabling with thermo-plastic insulation and plug connectors. The 20-core cables between the two rooms are similarly fitted. The cables are conveyed on drums in varying standard lengths and readily laid beside the line; no jointing or soldering is required. No trenches are used; the cables are suspended on messenger wires or laid on brackets where there is risk of damage from defective brake shoes or other items.

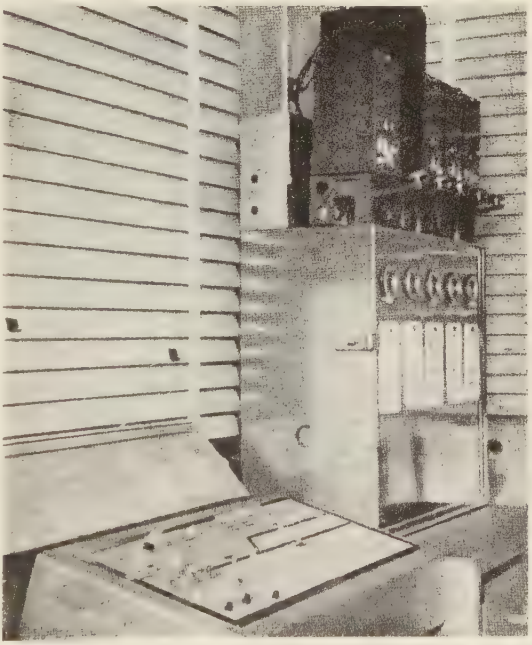
Practical results.

When this equipment was first used in 1958 at Pianotondo it was found that, with the points already laid in the northbound line and the two buildings put in position, the changeover to single-line working could be completed in 2 1/2 h without disturbing the traffic on that line. About 1 1/4-mile length of track was then completely renewed in under five weeks and double line working once more resumed.

The dense traffic over the Gotthard route, with corresponding wear and tear on the permanent way, renders it advisable to divide the long distances between some stations into two or more block sections, with permanent crossovers at each signal location, but even were the funds immediately available a long time would be needed to carry this out.

Meanwhile, the transportable equipment will continue to be used regularly between Arth-Goldau and Lugano. In 1959 it was applied between Gurtnellen and Wassen. To keep installation and storage costs to a minimum the outdoor apparatus, weighing in all some 10 t, is kept in a wagon, which can thus serve both to house it and transport it to site, as required.

We are indebted to Mr. R. Leemann, Signal Engineer, Second Division, Swiss Federal Railways, Lucerne, for the information on which this article is based.



Signalbox, showing magneto type interlocking block.

[656 .212 .6 (73)]

Mail hoists cut train delays.

(*Railway Age*, May. 16 1960.)

The Story at a Glance : Florida East Coast has developed a mechanized system that permits handling large volumes of mail without slowing down crack passenger trains. Mail destined for a particular point is loaded on dollies that can be hoisted on or off the car in half a minute. Both the FEC and the Post Office are happy with the operation. It speeds terminal-to-terminal operations and may help keep mail traffic on the rails.

Growth in mail traffic, which has duplicated Florida's population growth, presented the Florida East Coast with a problem : Crack trains were forced to make long station stops to allow time for handling large quantities of storage mail. To avoid delays and allow the trains to make their schedules, the FEC has been perfecting a system to mechanize this mail-handling operation.

The new system is now in use on two of the FEC's ten daily passenger trains. It involves the use of air-operated cranes permanently installed in storage mail cars, plus the use of special wheeled dollies on which mail bags are « palletized ». From initial terminals, and en route, mail due for delivery to intermediate stations is loaded on one or more dollies. The hoist can place the dollies on station platforms or directly on postoffice contractors' trucks. Mail due for dispatch from a station is loaded on one or more dollies before arrival of the train so that they can be quickly lifted into the storage mail car. It takes about 30 seconds to put one of the dollies on or off the car.

Two crane-equipped baggage cars, which have been in storage mail service since last fall, have mad it possible to reduce the average terminal-to-terminal time of FEC trains 5 and 6 between Jacksonville and Miami by approximately 25 min. These trains, the « City of Miami » and the « South Wind », operate between Chicago and Miami. Their on-time performance is of importance not only to the Florida East Coast, but also to its northern connections.

The new handling system was developed by Gordie Stewart, assistant chief operating officer of the FEC, and the mail-car installation is known on the FEC as the « Gordie Hoist ». The hoisting arrangement is suspended from a 3-ton Yale trolley which runs on an 8-in. I-beam that extends between the top plates over the centers of two side doors.

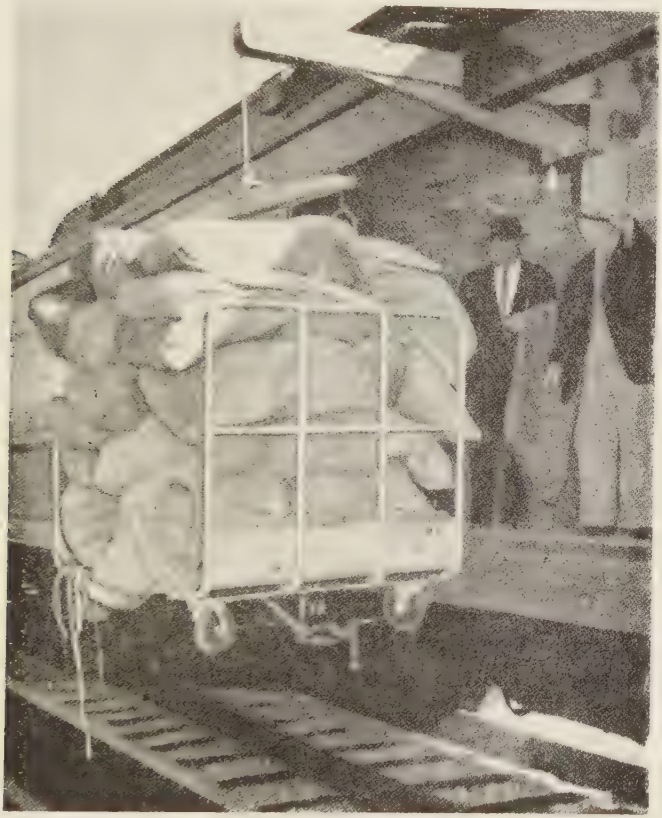
The trolley is powered by an air motor and sprocket drive which extends and retracts the boom through the side door. A 1 000-lb air hoist is mounted at one end of the boom, which is formed by a pair of 6-in.-wide steel bars. A link chain extends from the hoist over a pulley at the far end of the boom. A roller at the hoist end of this boom runs under the bottom flange of the I-beam to prevent tilting under heavy loads. The boom is pivoted under the trolley near the hoist so it can be swung 180 deg to be used through either side door. Air for the two air motors is taken from the brake system through a small reservoir applied to the car.

The FEC is altering the baggage cars which are being equipped with mail cranes. These changes are aimed at making possible utilization of the full width of the car at floor level. Two fan-type, ceiling-mounted heaters replace the steam coils on the car sides. The electrical locker is changed from the original vertical floor-to-ceiling arrangement to a new horizontal design, with the base of the cabinet 5 1/2 ft above the car floor. The tongue-and-groove car flooring

is covered with Masonite to give a smooth surface on which to roll the dollies.

Extreme lateral movement of the trolley on the beam between the car doors extends the end of the boom approximately 40 in. beyond the car side. Once inside, a dolly can be placed about 45 in. from the center line of the I-beam between the door openings.

The dollies were designed and built by the FEC. They have 3/4-in. iron pipe frames, sheet-metal floors, and have the following over-all dimensions: length, 4 ft; width, 3 ft 4 in.; height, 3 ft 2 in. Use of tubular aluminium frames is being considered. Dollies are equipped with rubber-tyred casters and a foot brake. A dolly will hold from 25 to 35 bags of mail weighing approximately 1 000 lb.



Mechanized mail-handling enabled the FEC to reduce average terminal-to-terminal time of crack passenger trains. It may prevent diversion of mail traffic to other transport media.

The FEC now has 28 of the dollies in service, and is handling the storage mail at nine intermediate stations.

When the operation is completely mechanized, each station will be provided with from one to six dollies, depending on the volume of mail handled. Each car

equipped with a hoist will be provided with six dollies which will be loaded at the initial terminal with mail for the first, second, and possibly the third stations. For each dolly that is set off, one will be picked up to keep the same number in the car at all times.

It is now planned to provide driveways at all stations to enable U.S. Mail and express trucks to receive and deliver directly to and from cars. This will eliminate intermediate handling over baggage trucks.

With just six months of service, the new system is working well. It permits handling larger volumes of mail on faster trains. This is attractive to the Post Office Department which has been impressed with the operation during inspections and may prevent diversion of mail traffic to other methods of transportation.

Car interiors will be rearranged to provide space in which dollies can be maneuvered. Mail bags are « palletized » on the special dollies, designed and built by the FEC.

[656 .25 (73)]

Planning the C & O's CLIC — The economics of data communications,

by Paul A. Flanagan,

Superintendent Communications Chesapeake and Ohio Railway.

(*Railway Signaling and Communication*, July 1960.)

In this paper, presented before the AAR Communications Section Convention in Detroit, Mr. Flanagan explains the methods the C & O used in estimating costs of the communications system required for their Car Location Information Center.

This paper deals with some of the economic aspects of data handling as related to communication. It is based on experience gained through association with our data handling program on the Chesapeake and Ohio Railway. A program conceived at a general staff meeting during July of 1953 that resulted in the formation of a task force immediately thereafter to study and recommend suitable circuits and equipment to implement mechanized handling of car information.

At the beginning of our Alice in Wonderland adventure in data handling we were most intrigued by what was then known as the « One Shot Method » approach. Simply stated, in case it may be lost in antiquity, it was then described as a method of operation wherein the initial manual conversion of data from the source document to a machine language would suffice for all subsequent operations. Having selected the document, in this case the train waybill and the data processing system, IBM punched cards, we were ready for the simpler things. To wit, things like how to transport data on some 4 500 or more cars a day from 275 separate locations to a data handling center, and at the same time deliver one or two lines of information on all cars passing from yard to yard prior to train arrival.

From July of 1953 through the year 1954 the task force group studied various phases of the over-all problem. Early in 1955 recommendations were made that a system teletype network be provided as the communication link to be used, with the IBM card handling equipment decided upon as the data processing medium.

To better detail and determine our specific requirements the over-all project was broken down into four, more or less separate and distinct, categories :

1. Input, including points of pick-up, volume expected at each point, time available for data preparation and tolerable delay in transmission.

2. Output, including the form in which data must be delivered to the processing center, timing and consequences of errors in data preparation or transmission.

3. Data Processing, including volume expected, time available for processing and the form in which it must be compiled for distribution.

4. Distribution, including points that will receive information, volume to be delivered to each location and revertive traffic load expected to result from original delivery of information, or requests for information not initially provided.

A separate study was also made of the possible labor implications of changing from one type of operation to another. A most important consideration if a project is to be consummated with any degree of permanent satisfaction.

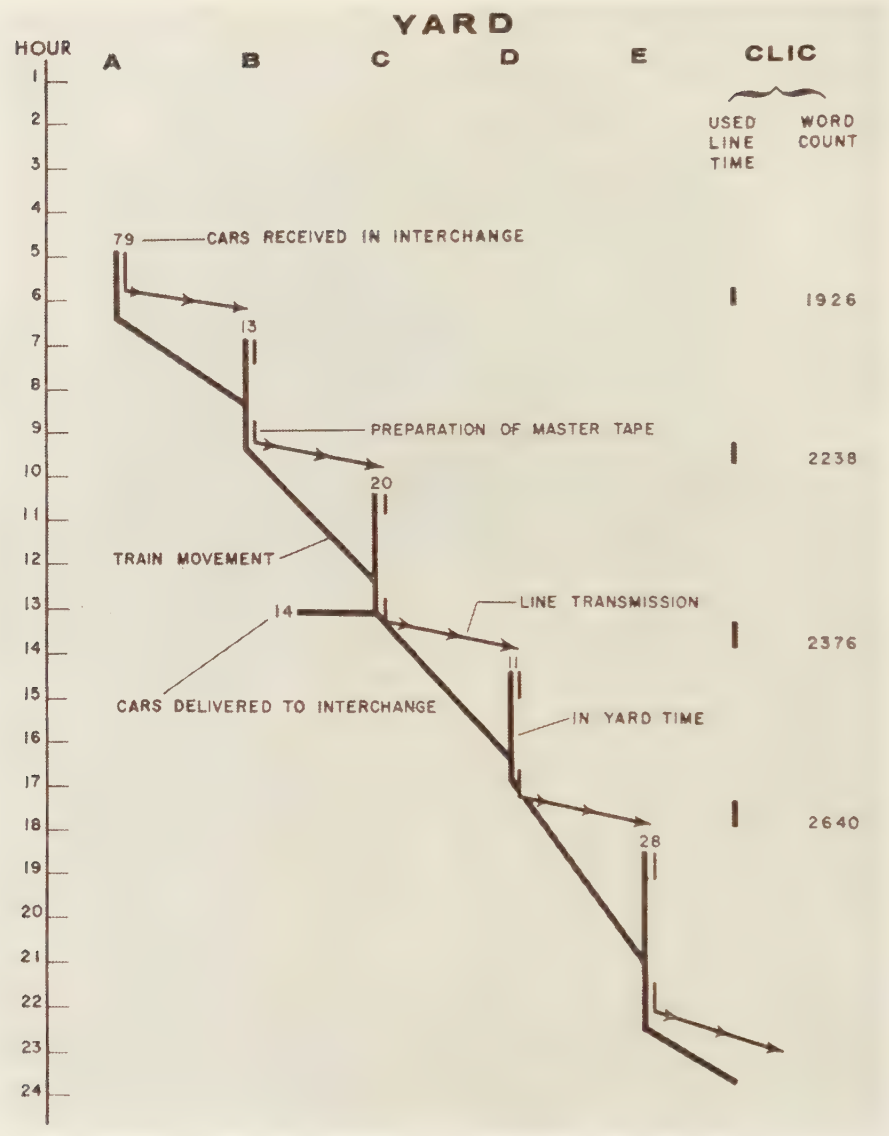


Fig. 1. Consist preparation and transmission as related to train movement.

Only items one and two, Input and Output, will be discussed here, as these involve the communication facilities. The chart in figure 1 shows graphically some of the important factors that must be considered to plan an adequate teletype facility to handle consist information. In this instance the train consist furnished the basic data from which various operating, sales and accounting information will be derived.

Figure 1 illustrates the progress of a single manifest train from yard A to yard B, yard B to yard C, yard C to yard D, then eastward to yard E. Actually, in this case, yard A and yard E may be considered main terminals, yard A being a point where a train is made up and yard E where it is completely reclassified and one or more new trains formed.

Time, as associated with train movement and yard operations, is indicated by a 24-hour clock at the left.

Starting at the top left hand side of the chart at yard A you will note that 79 cars were received in interchange at 500 or 5 AM, and that the train departed at 630 or 6:30 AM. The cars received in interchange were in the yard one and one-half hour as indicated by the vertical line from 500 to 630. The time required to prepare unit tapes on each car and run off a master tape for line transmission amounted to approximately 53 minutes, as indicated by the short vertical line to the right of the cars received in interchange line. On completion of the master tape, line transmission was started immediately as shown by the horizontal arrowed line to the right. The consist is received in completed form at yard B at 615, or about fifteen minutes before train departure from yard A. The information is simultaneously received at CLIC, the Car Location Information Center. In this case the transmission is shown as being made at 75 WPM, consuming about 26 minutes of line time.

As a general rule, we found that there was adequate time to prepare and transmit consist data from an originating terminal to the next intermediate yard well in advance of the trains arrival, as in this case from yard A to yard B.

Problems at intermediate yards.

At intermediate yard B the situation is a little different. Here, we have on hand the tape and hard copy for a switch list received from yard A well in advance of the trains arrival, and sometime later we receive the waybills on the 13 cars picked up locally and proceed to prepare unit tapes on these cars. Now, that is about as far as we dare go until the train has arrived and we have determined that there were no pick-ups or bad order set-offs enroute, and until the 13 cars received locally have been switched into the train and the train checked as to car order. Usually the train check list is available about the time of train departure or shortly thereafter. The master tape is then prepared and line transmission begun as indicated by the short vertical line and horizontal arrowed line to the right of yard location B. For all practical purposes the same routine is followed at intermediate yard locations C and D, and at terminal E.

Number of information lines vary.

For all cars originating on line or received in interchange the equivalent of 2 or 2 1/2 lines of information is transmitted to the next yard and direct to CLIC. However, the next yard requires only the first line of information for operational purposes. This makes it necessary for each intermediate yard to tear the continuous tape received from another yard into unit car tapes, delete line two and any additional information, and store until all waybills on cars received locally are available and two lines tapes have been cut. When this has been done and the train order determined a master tape may be cut for line transmission.

With the exception of the tape received from yard A, which contains all two line reportings, all other tapes received at the Car Location Information Center will generally have both originating, two line information, and passing, single line information, in varying order depending on location of cars in the train.

Referring to the word count column at the extreme right hand side of the illustration, you will note that the word volume for each train movement from yard to yard is indicated. There are 123 two line reportings on cars received in interchange or locally along line, and 249 single line

passings reported, or a total of 495 lines of information, equivalent to roughly 5 940 words. The total words received at CLIC amounts to 9 180. The difference of 3 240 words covers addresses, statistical headings, summary and signature, etc., required to identify transmissions for operational and data handling purposes.

In a general way this describes the movement of a single train over a given route. In actual operations there will usually be several train movements taking place simultaneously on a given territory in any 24 h period. Trains will be moving in both an eastbound and a westbound direction and arriving at yard locations at various times determined by schedules and operating conditions. Experience has shown that it is possible to predict, with a fair degree of accuracy, the arrival and departure time of trains at yard locations if the past train performance records are studied for a representative period of time. Actually, this is one of the more important considerations in determining circuit requirements, in that the handling of peak period word volume without undue delay is a must if the system is to function with any degree of efficiency.

A very simplified version of a composite of several train movements over a given route is shown here in figure 2. In this case we have four trains, two eastbound X and Y, and two westbound X and Y, operating between yards A and E, and passing through yards B, C and D enroute. The black vertical lines, as an example under eastbound train X, between A and B, represents the time available to prepare consist data and transmit it, in this case from yard A to yard B. The same is true for the vertical lines under eastbound train X between yards B and C, etc. The measure of time denoted by the vertical black lines consists of a combination of several things. First, when the preparation of a consist could conceivably start, or when the information necessary to permit tape preparation should be available to the yard. Second, a portion of the trains running time between yards, or the cut-off time when consist tape must be transmitted to the next yard to assure its receipt sufficiently in advance of train arrival to permit switching and yard handling. Generally stated, the vertical line represents the amount of time within specified periods wherein certain data handling operations must be completed. For purposes of reference the word volume is indicated for each operation to the right of the vertical lines. As an example, between yard A and B, under eastbound train X you will note 1926 words are shown. Such a layout serves only one purpose, the determination of peak load periods.

In this particular case, train movement density fell between the hours of approximately 845 and 2 300, using the 24 h clock. Converting the words to equivalent time intervals for 60 WPM operations, you will note under the eastbound movements that there is no apparent load problem. The same holds true for the westbound movement at the word volume indicated and 60 WPM operations. However, a combination of both eastbound and westbound consist traffic on a single 60 WPM circuit, could under conditions of train delays, line trouble, and other unforeseen conditions, result in accumulative delays that would defeat the purpose of the system. Equating the same word volumes into time for 75 WPM speeds indicates that, as a minimum, a buffer insurance in time of at least 50 % under normal operating conditions should be provided. Our actual experience indicates that this is a reasonable minimum figure. Any less allowance for contingencies will surely result in excessive delays as a rule rather than as an exception.

Based on the peak load periods and need for additional line time to take care of contingencies we have our choice of two or more possible circuit configurations to fill the consist traffic conditions graphically illustrated in figure 2. For purposes of discussion let us say that we consider either two 60 WPM circuits or one 75 WPM as sufficient to fulfill our requirements as shown here in figure 3. First, it is to be noted that if we assign one of the two 60 WPM circuits as a westbound

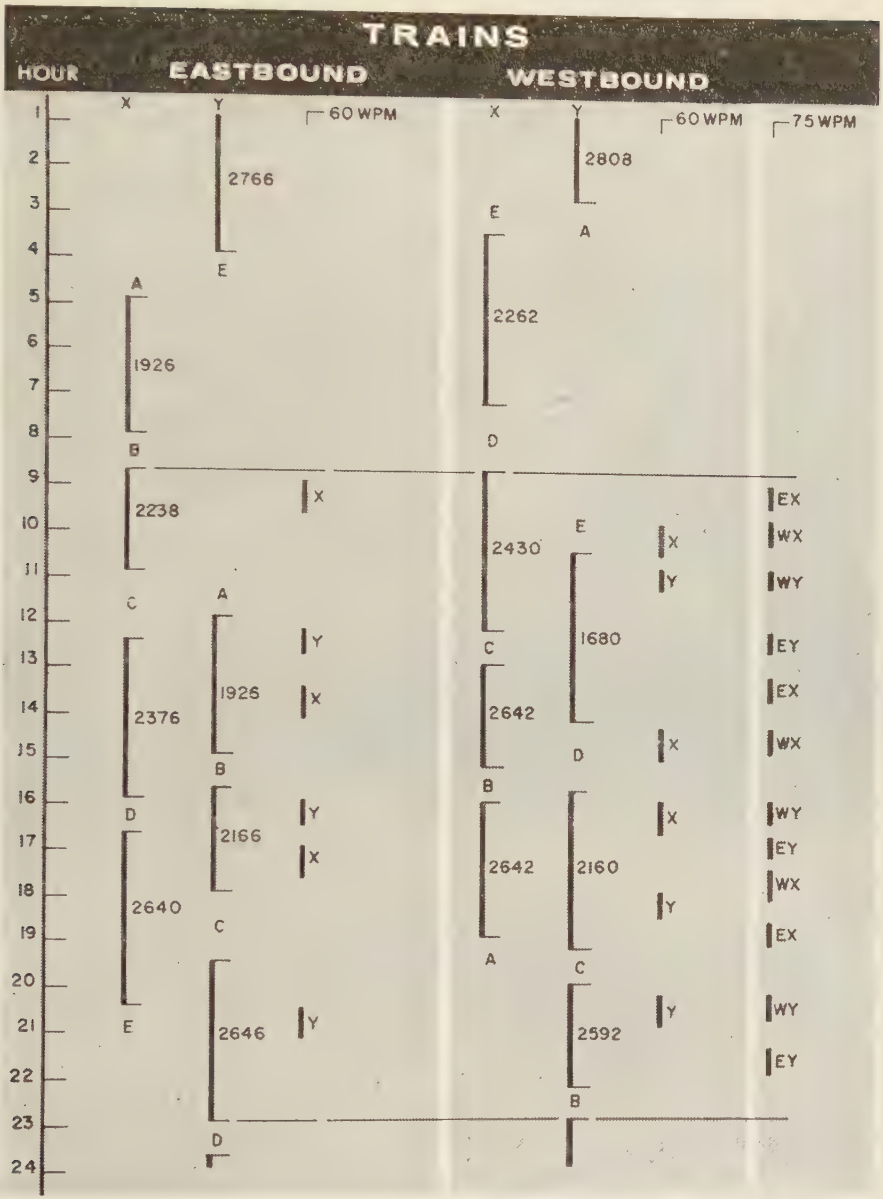


Fig. 2. — Time available to prepare and transmit consist data for several trains.

circuit and the other as an eastbound circuit some savings in equipment may be achieved. This is brought about by the fact that at yards where we have separate eastbound and westbound yard office, and the consist information follows the flow of traffic, transmissions would be from an eastbound yard office at one location to

the eastbound yard office at the other location. The same condition of course being true for westbound train and consist movements. However, at yard locations where all clerical work is consolidated in a single office it is necessary to provide equipment on both circuits.

With 75 WPM operations as shown in the lower circuit layout plan, worth-while savings in equipment will be possible. This is a very desirable objective as the major cost for leased teletype facilities at this time may be assigned to equipment.

Relative costs of equipment.

The relative cost for two 60 WPM circuits as compared with a single 75 WPM circuit is shown in figure 4. It will be noted that the rental difference amounts to $ 789.94 monthly. The theoretical capacity of the two 60 WPM circuits operated 24 h a day 30 days a month is about 432 000 lines of information. Based on a monthly rental of $ 2 278.30 this works out to be about $ 0.0053 per line of information. The theoretical capacity of the single 75 WPM circuit is around 270 333 lines of information at a cost per line of about $ 0.0055. And to carry the matter further, if 100 WPM operations were considered the capacity would be 360 000 lines at a cost of about $ 0.0049 per line.

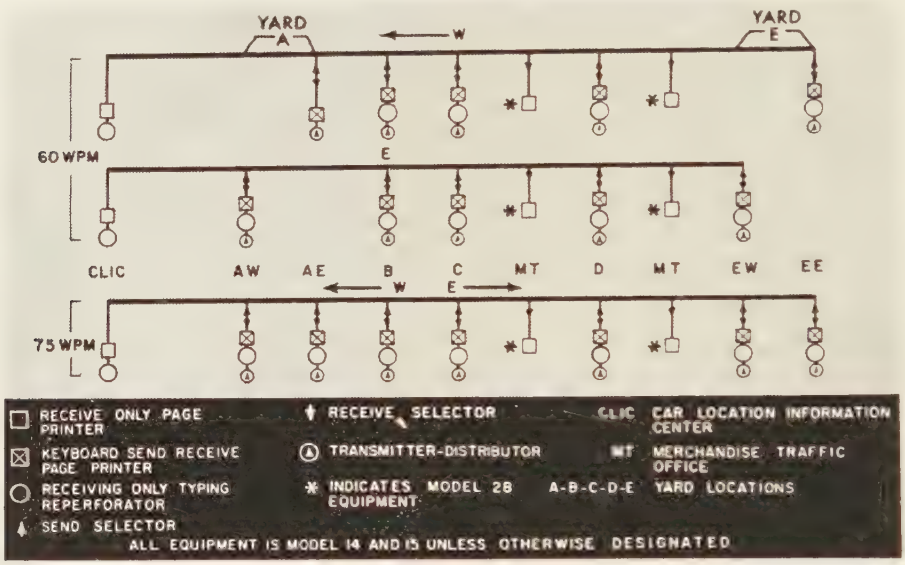


Fig. 3. — Comparing equipment needed for operation at 60 and 75 words per minute

In the particular circuit under consideration the actual requirements were for a circuit that would provide a working capacity of 3 000 lines with an equivalent of 1 500 lines of spare time each 24 h. On the basis of a 30 day month this would amount to 135 000 lines of information. The approximate cost per line of information for this particular load requirement at the various operating speeds is: two 60 WPM circuits, $ 0.017; one 75 WPM, $ 0.011; and one 100 WPM, $ 0.013. This serves to point up the fact that line circuits and equipment should be engineered as close as possible to actual service requirements when leased facilities are employed for data handling purposes.

Figure 4 also includes a graph of cost per line of teletype information based on 60, 75 and 100 WPM operations. This graph represents volume figures for a 24 h period and prorated facility cost of the same interval. Inasmuch as this graph was

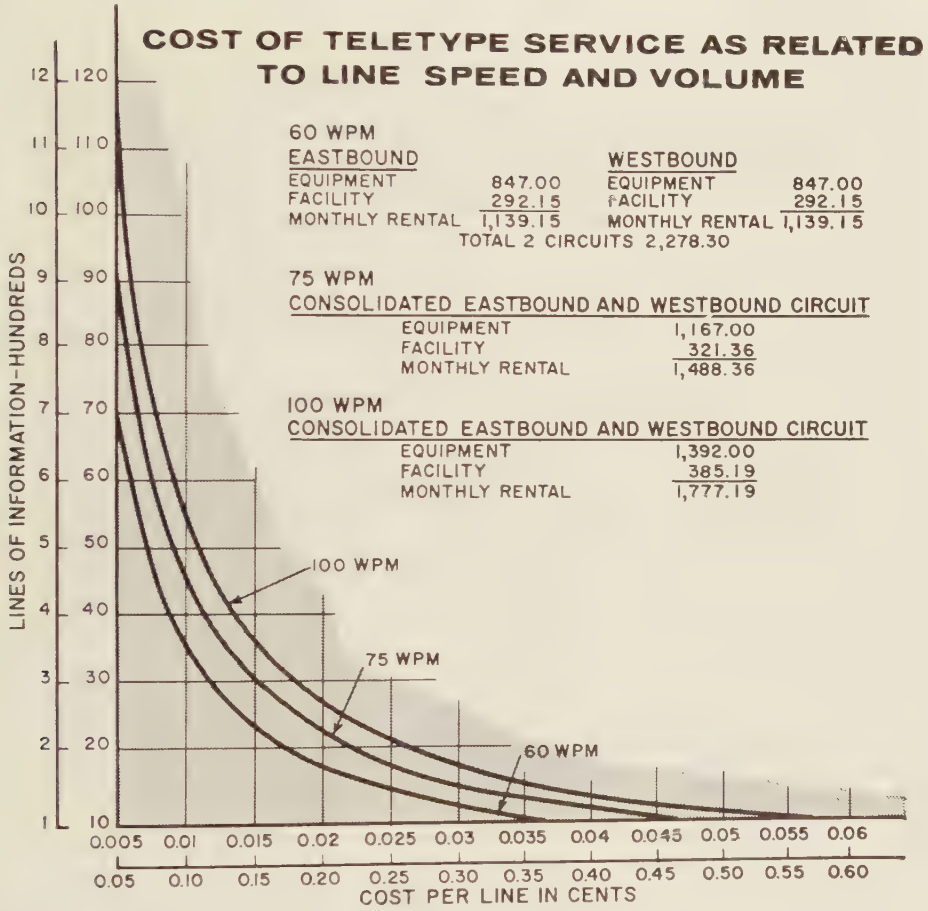


Fig. 4. — A graph of facility cost per line, at several speeds, for 24 h.

based on the composite facility cost for all leased teletype service used in consist data handling, it has proven of some value in determining average cost for service based on day to day volumes. It also permits a rapid determination of when consideration should be given to changes in circuit operating speeds, either upward or downward.

The standard data preparation equipment in our yard offices consists of an assembly of conventional teletype equipment units. The various pieces of equipment being physically arranged to permit the convenient conversion of waybill information into five level teletype tape.

The essential units required are shown in figure 5, and consist of a Keyboard Send-Receive Page Printer, an Automatic Tape

Transmitter-Distributor with end of tape switch and tape release lever (free wheeling gate), a Typing Reperforator with tape back spacer and a local battery supply. This small amount of equipment, sufficiently compact to fit into the smallest yard office will permit the manufacture of consist data in a legible form for yard to yard operational purposes, and at the same time provide a suitable input for data handling equipment.

The typical current average rental cost for such equipment when obtained from an associated Bell company is approximately as follows :

15 KSR Page Printer	$ 30.00
14 ROTR with tape back spacer	25.50
14 ATR with end of tape switch and tape release lever	20.50
3 75 speed charges (*a*) $ 2.50	7.50
	$ 83.50

The listed charges are about average charges for equipment, based on tariffs in effect for ten of the associated Bell companies operating in the various states the C & O serves. As an example, the rates for a model 15 Page Printer varies from a low of $ 25.00 for one company to a high of $ 35.00 for another company. The over-all rental cost for a basic teletype tape factory is very low and including fanfold sprocket feed paper, teletype tape and ribbons for the printer and typing-reperforator, probably represents a minimum for a workable data originating station.

Some of our studies indicate that the average cost per line of information (equivalent to seventy two characters or twelve words), including equipment rental, paper, tape and ribbons is about $ 0.0025 or $ 0.005 per car per reporting location, based on two lines of information for each car.

In this particular study labor costs at yard locations were not considered, as the operation did not require additional manpower or permit a reduction in existing forces. Let us say that it was a case of engineering a work load to meet a labor situation, and obtain in the process a worth-while by-product. The by-product being a teletype tape suitable for line transmission and data processing.

While the usual mixed train consist probably represents better than 85 % of the total data prepared and transmitted on line, there are a few consists such as an ore train consist that contains a large volume of repetitive information. Ore trains are usually solid trains loaded from one ship and billed to a single destination. All of the information after the heading and following each individual car initial and number is identical and lends itself to automatic insertion in a master tape.

Teletype equipment readily lends itself to special adaptations for data handling purposes. One of the simpler modifications, taking advantage of the Stunt Box functional selector mechanism incorporated in a 28 KSR machine, is the fixed programmed tape factory shown in figure 5. The term « programmed » being used in the sense that certain assigned functional operations have been added to the assembly to perform a given task. As will be noted, this assembly of equipment consists of a 28 KSR machine with Stunt Box, a 14 Typing-Reperforator with tape back spacer, a 14 Multiple-Gate Transmitter-Distributor with end-of-tape switch and tape release lever, a relay control cabinet and local power supply. This assembly will perform several very useful data handling operations.

In addition to functioning as a standard tape factory for the preparation of consist tapes for unit records and preparation of a master tape for line transmission, the arrangement will also permit the insertion of repetitive information in a continuous tape in format when non-repetitive information is fed into gate number 3, and the repetitive information in a loop tape is in gate number 1. The operation is such that functional switching characters punched in the tape containing variable information, and similar functional characters in the loop tape to perform flip-flop switching, are either absorbed in the switch-

ing operation or appear as blanks in the output tape. The tape thus prepared is clean of functional character codes that could interfere with transmission on a sequential calling automatic start teletype system, switching through a relay center, or effect operations of IBM 047 tape-to-card end-of-tape switch on the gate in operation.

At present, the typical average monthly rental cost for such equipment when obtained from one of the associated Bell companies runs about as follows, for 75 WPM operations:

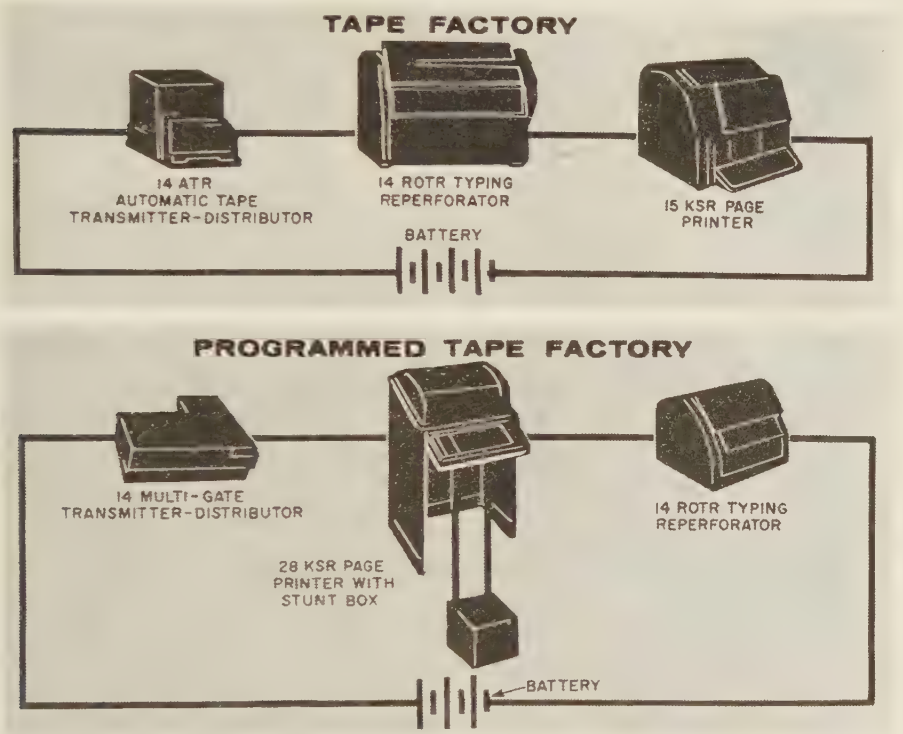


Fig. 5 Average monthly rentals: tape factory, $ 83.50; programmed factory, $ 133.00.

machines. A good example of the use of this arrangement of equipment is the insertion of repetitive information in an ore train consist.

The preparation of master tapes from unit car tapes is also expedited by the alternate feeding of unit tapes into gates number 2 and number 3. In this case the automatic start feature of the alternate gate containing a tape is initiated by the

28 KSR with sprocket feed platen . . .	$ 35.00
14 Multi-Gate Transmitter-Distributor with end of tape switches and tape release levers	55.00
14 Typing-Reperforator with tape back spacer	25.50
Stunt Box and Relay Control. . . .	10.00
3 75 WPM speed charges (*a*) 2.50 . .	7.50
	$ 133.00

This cost represents an increase of $ 49.50 in monthly rental over the cost for a conventional tape factory as previously described. The justification for this increase is easily achieved in that through its use it is possible to perform approximately 33 %, more work over a 24 h period when the handling of repetitive information, such as data handling. In the study the transceivers were used on a full period leased telephone circuit arranged for alternate talking and data handling service. In this manner tests could be conducted on transmission speeds, error rate and effect of various machine programming during the hours when the circuits used for conver-

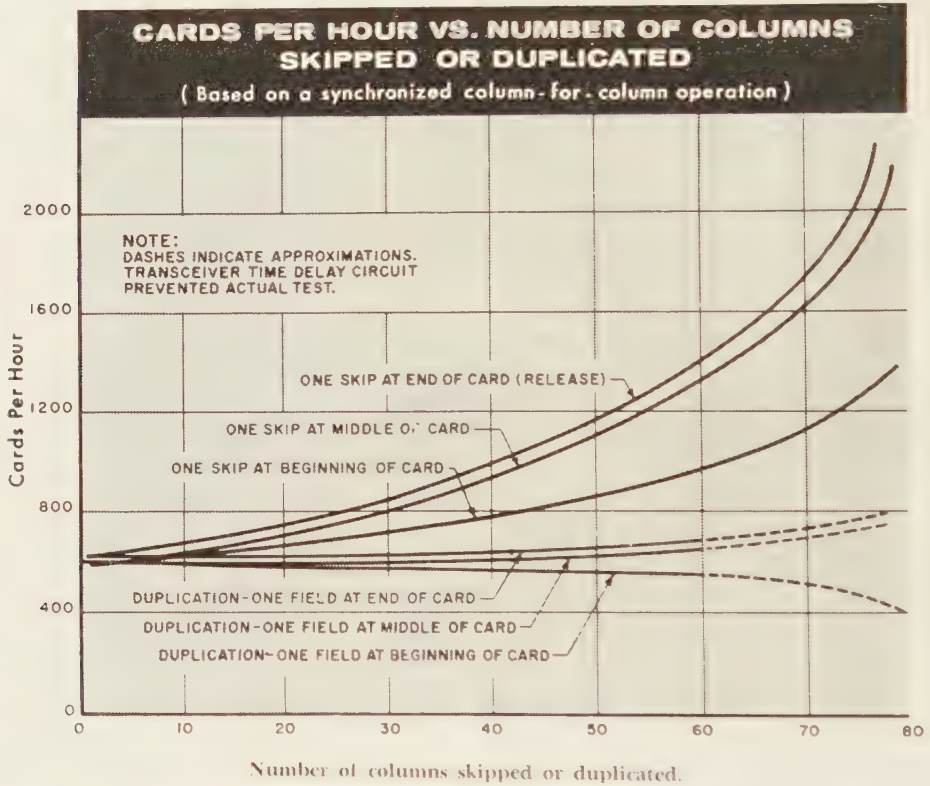


Fig. 6. — Transceiver card output. Full 80 column transmission is most efficient

preparation of ore consists, is necessary. In other words you might say its use added the equivalent of one man twelve days a month, that would have cost $ 233, not including overhead.

Studied use of transceivers.

Some very limited studies were made of the use of IBM Transceivers for consist sational purposes were at a minimum. The tests indicated that the type of programming employed could materially effect the transmission speed. The results of some of our tests are indicated in figure 6. This graph indicates the results of a series of short tests made for the purpose of establishing machine running time of various programs. Groups of 25 or 50 cards were transmitted, using more than 150 different

programs, and the elapsed time of each run recorded.

The curves in figure 6 were developed from the results of these tests. They may be used to approximate the number of cards produced per hour where the operations are synchronized column for column between transmitter and receiver. The curves are based on a single field of skipping or duplication at different positions of the card as indicated. Although the card volume increases as the number of columns skipped or duplicated increases, the number of characters transmitted per hour decreases. Thus, the most efficient operation in terms of telephone circuit time is 80-column transmission and reception.

The number of cards produced by operations where there are two or more fields of skipping or duplication may be approximated by locating the point on the curve which would be the output if there were only one field of the same total length. The result thus obtained should be reduced by about 5 % for each restart more than one in the program.

Programming would have been of considerable benefit had it been possible to use it in our operations. However, in our case, to accommodate all the information required for an original reporting would result in the use of two 80-column cards. Our requirements were, for all practical purposes, equivalent to two lines of teletype information, or the equivalent of at least 120 characters. This would mean a minimum of two 80-column cards would be required, and as programming can only be accomplished on a single card basis, this desirable feature could not be used. We did study the possibilities of transmitting single line passing report information using a synchronized column for column program for 72 columns, skipping from column 73 through column 80. The effective speed was found to be about 130 wards per min, or eleven IBM cards.

Including rental costs for Manual Card Punch, 066 Reading and Punching Unit, 068 Telephone Signal Unit, IBM cards and circuit facilities, the cost per line of information was calculated to be around $ 0.028.

The equivalent cost for teletype service at 75 WPM was calculated to be about $ 0.005 for local tape preparation and $ 0.011 for line transmission, or a total of $ 0.016 per line per transmission. The difference of $ 0.012 per line in our case would have resulted in an increase of over $ 8 000 a month based on the average volume of 675 000 lines handled.

Evaluating labor costs.

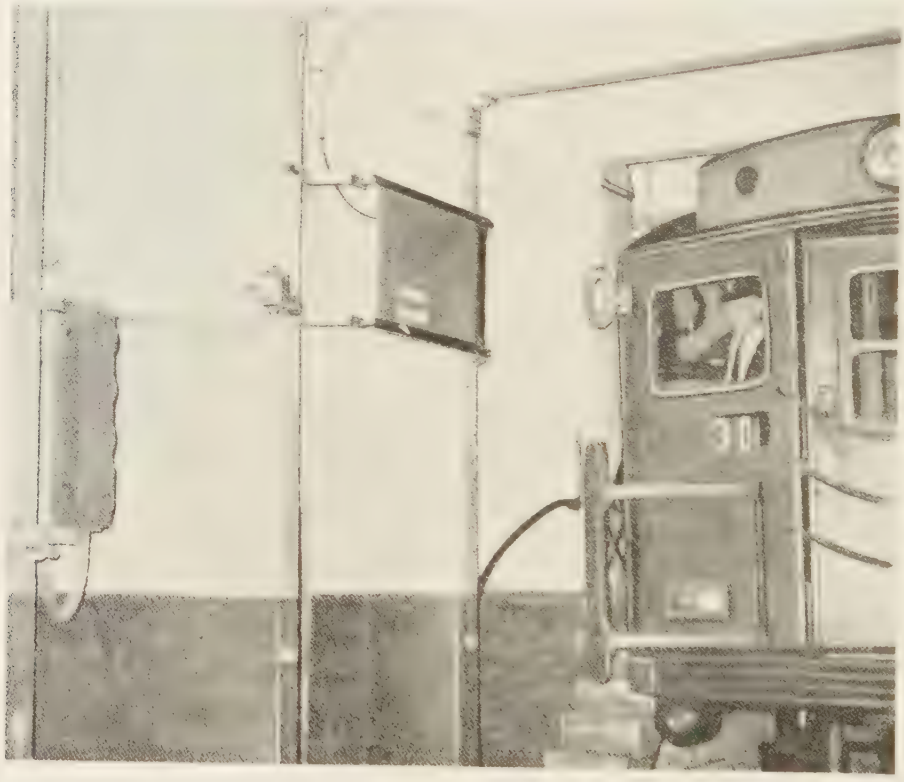
Attempts have been made to evaluate and compare the labor costs involved in the various operations, that is teletype, IBM Transceivers, and combinations of these operations. So far we have not been successful in arriving at dependable figures. To properly produce reliable cost figures on such work it is necessary to determine actual division of each yard clerk's time between date handling tasks and other tasks. An individual study of over 425 positions with varying wage scales would be necessary. The time has not been available for such a detailed study. It is sufficient to say that the conversion to teletype data handling for all practical purposes was done in the yard offices without need for increases in manpower. Our study of the cost for communication facilities assigned to data handling is a continuing program, and it is expected to produce additional savings in communication facility costs without a reduction in data handling efficiency.

[625 .4 (73) & 656 .25 (73)]

Subway trains route themselves.

(Railway Signaling and Communications, June 1960.)

Because of the congestion developing in the central portion of the Broad Street subway line, the City of Philadelphia decided to smooth out the passenger load by the additional miles of express track with the associated signaling system. An important adjunct to the signal system was the extensive train identification system, called



A southward train, about to identify itself at Hunting Park, will select a route at Erie either to the express track or local track.

operation of express trains. When the subway was built, a four-track right-of-way was provided from Walnut-Locust to the yards at Fern Rock. The present $5 million improvement involved the laying of 5.21 « Identra », for the automatic routing of trains.

The Identra system consists of a demountable, train carried, inert tuned coil and wayside coils and equipment. The train

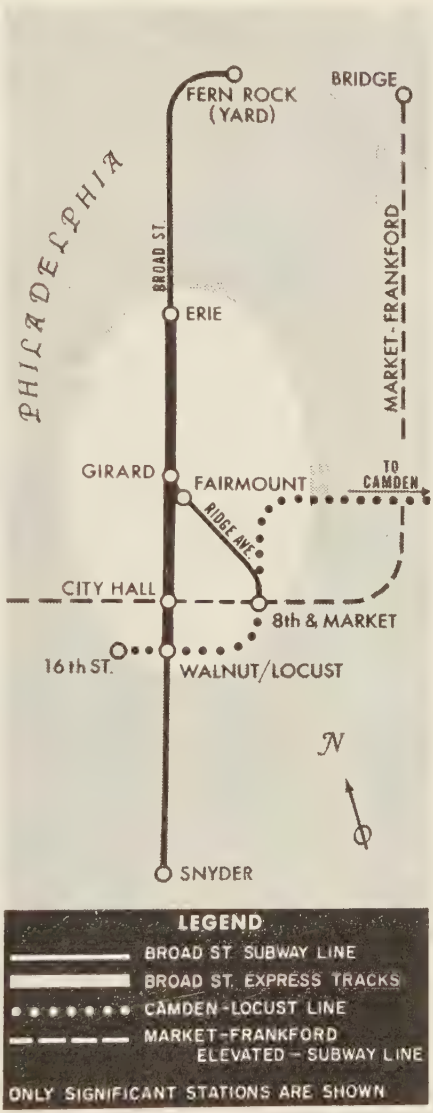
coil, carried on the upper right front of the train, includes a rotary switch and a capacitor box. The rotary switch permits the choice of nine different frequencies, by changing the capacitance in the tuned circuit. The nine frequency Identra system was designed especially for the Philadelphia Broad Street subway installation. Previous Identra installations had fewer identities. All trains in passenger service on the Broad Street subway system, including the Ridge Avenue and Camden lines, carry a coil.

The wayside equipment consists of an instrument case and a pair of coils. The coils are positioned one on top of the other, each in a vertical plane parallel to the rails, opposite and 17 in. from the train-carried coil. One of these coils is connected to the input, the other to the output of a two-stage resistance coupled amplifier. The two coils must be carefully positioned to reduce the mutual magnetic coupling to zero, thereby preventing oscillation in the amplifier.

When the train-carried coil enters the magnetic field of the wayside coils, the mutual coupling causes the amplifier to oscillate. The frequency of this oscillation is determined by the resonant frequency of the coil and capacitor in the train-carried unit. This oscillation signal from the amplifier is then applied to the frequency selective networks, which are essentially band-pass filters, each sensitive to a different channel or band of frequencies. The network that coincides with the frequency of the input signal from the amplifier accepts this signal, then rectifies it and applies the resultant D.C. to the coil of a style KP relay, causing it to pick up and operate an external control circuit. The networks tuned to other channels reject the input signal and hence the corresponding control relays do not operate.

Need three wayside units.

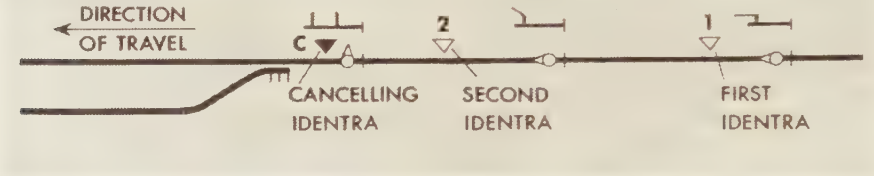
At each location where it is desired to identify a train, three sets of wayside equipment are provided: a first identification point, a second identification point, and a



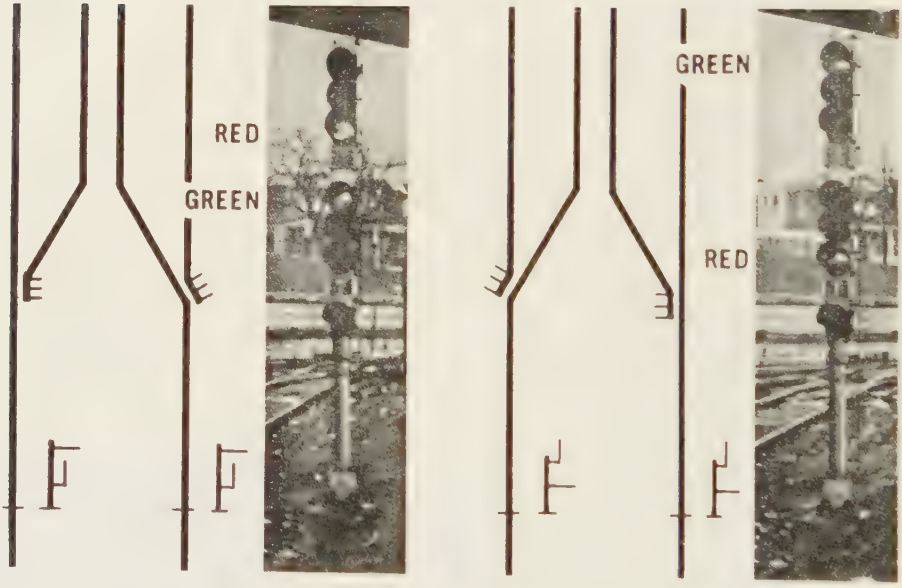
The Broad St. subway was built by the city in 1925 with provision for four tracks north of Walnut-Locust. The Delaware River Port Authority built the line from 8th and Market to downtown Camden, N.J. Express tracks have been installed from Walnut-Locust to Erie and a train identification system employed to route the trains. The Philadelphia Transportation Co., a private company, operates the system.

cancelling point. The first identification point is located sufficiently in advance of the controlled location that switches have time to operate and signals to clear to the least restrictive indication possible.

A second identification point is located shortly before the home signal. Although there are two stop signals behind each train, the motorman on a second train may « key-by » the rearmost stop signal by operating a small lever on the signal. When trains have close headways, a second train may pass the first identification point before the first train passes the canceling point, and hence the second train would not register a route in the Identra equipment. This closely following second train will then select its route at the second identification



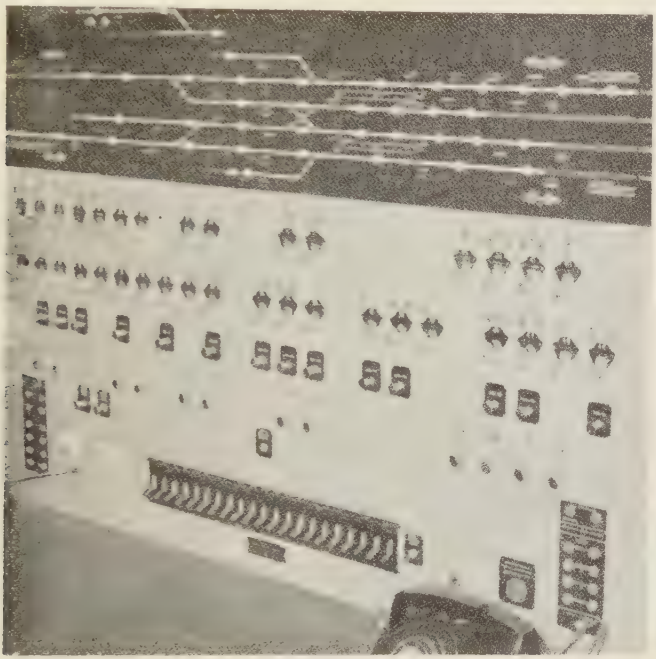
Three sets of Identra equipment are provided at each routing location.



Route signaling is used: at interlockings the top arm indicates the condition of the right hand route, the lower arm the condition of the left hand route. The « T » indicates « Tower controlled » and the bottom unit is a call-on signal. A yellow, instead of green, is displayed if the next signal is at stop. The yellow aspect indicates « approach next signal prepared to stop », and carries no speed restriction. Timed signals are used to enforce speed restrictions

point. This method is preferable to storing identifications from the first location for more than one train, as it eliminates the possibility of a storing system fault misrouting trains.

The canceling location is just past the home signal. It is a wide bandpass unit and accepts any coil tuning to clear the Identra equipment for the next train selection.



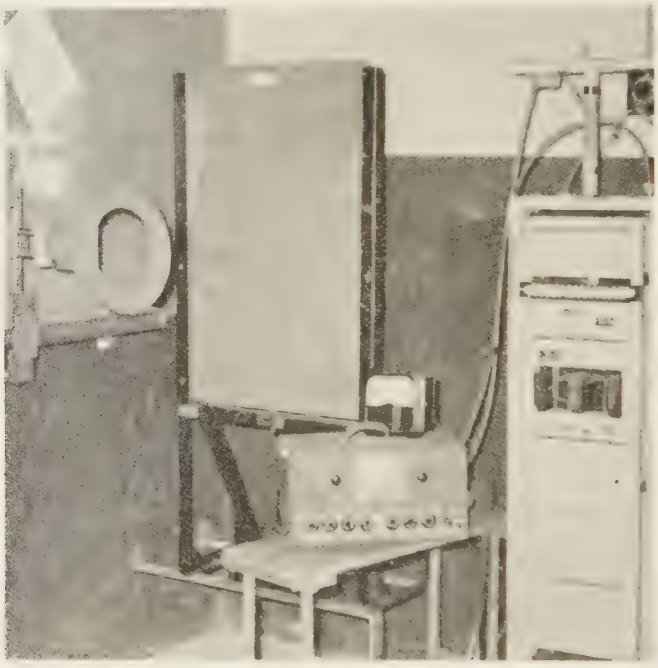
The control machine at Erie tower is normally unattended. Beneath the switch and signal levers are a row of spring return call-on pushbuttons. Beneath these are the sealed emergency release pushbuttons. A signal maintainer's key operated emergency circuit controller is at the lower right. Contact rail power is indicated by the lights in both lower corners. The two levers left of the telephone keys hold trains on the local turn-back tracks.

Trainman can change route.

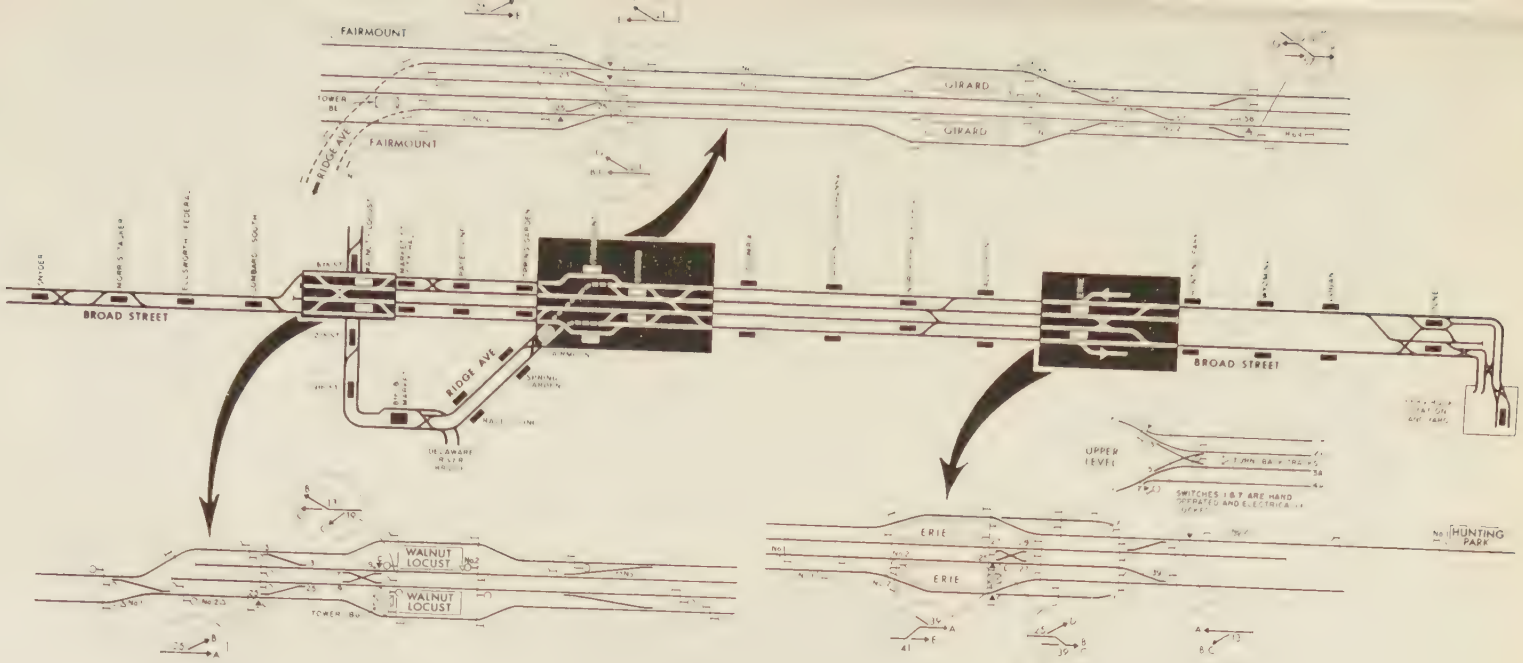
In the event an incorrect route is established due to an incorrect setting of the selector switch or to a failure of the Identra equipment, the motorman can change the routing at each turnout by depressing a pushbutton for the desired route. A pushbutton and a white light for each route (switch normal, switch reversed) is mounted 11 ft. in advance of the home signal governing moves over that switch. The motorman will depress the button corresponding to the desired route and the associated white lamp will light to indicate that the request for the change of route has been established. The signal, which had been cleared for the incorrect route, will go to stop. After the time locking

is released, about one minute, the switches will throw and the signal will clear for the new route. The white lamp at the pushbutton is extinguished automatically by the passage of the train into the next track circuit. It is also required that the motorman notify the dispatcher whenever it is necessary to change the route, so that corrective action may be undertaken.

Table 1 lists the selector positions on the train carried coil, the resonant frequency, and the route it selects. In only one case is it necessary for the selector to be changed enroute : the motorman of a train originating at 8th and Market and going to the shops at Fern Rock must change the selector from « E » to « A » at the Girard station, or any station before Erie. The « E » position routes him onto the local track north of Fairmount heading for the turnback at Erie; the « A » position routes him to the through local track at Erie. Otherwise, once the selector is positioned at the beginning of a tour of duty, it need only be changed if the terminals of his run change. The motorman carries the coil from one end of the train to the other at each terminal.



A complete set of Identra equipment in the signal shop provided testing facilities. The train coil is mounted on a bracket which slides on a steel bar so that the train coil may be moved towards or away from the wayside coil. The maximum distance at which the relay in the frequency selective circuit will pick up provides a « figure of sensitivity ». The selective frequency of the wayside unit may be changed by changing plug-in filter units.



IDENTRA ROUTING SELECTIONS FOR BROAD STREET SUBWAY.

SWITCH POSITION.	RESONANT FREQUENCY.	TYPE OF SERVICE.	TERMINALS OF ROUTE.
A	85 KC	LOCAL	FERN ROCK — SNYDER
B	92 KC	EXPRESS	FERN ROCK — SNYDER
C	100 KC	EXPRESS	FERN ROCK — WALNUT-LOCUST
D (*)	108 KC	EXPRESS	ERIE — WALNUT-LOCUST
E	117 KC	LOCAL	ERIE — EIGHTH AND MARKET
F (*)	126 KC	EXPRESS	ERIE — EIGHTH AND MARKET
G	136 KC	LOCAL	GIRARD — EIGHTH AND MARKET
H (*)	146 KC	EXPRESS	FERN ROCK — EIGHTH AND MARKET
I	156 KC	LOCAL	ERIE — SNYDER

(*) Not yet in use.

Busy interlocking is unattended.

The Erie Avenue interlocking is the busiest on the system. This point is the north end of the express tracks and both express and local trains may turn back here. The local turn-back tracks are located on an upper level. The all-relay interlocking has a miniature free lever control machine which can control all switch and signal functions in the interlocking. While the machine is not large by railroad standards, it has been determined that with trains on two-minute headways on four tracks, one man alone would have to be extremely alert to operate the machine manually.

The train coil switch allows the choice of nine frequencies and off.

The interlocking circuits are so designed that either automatic or manual operation may be selected by operating a master lever. When the interlocking is in automatic operation, it operates with an unattended tower. Routes are then established by the Identra train identification system and track occupancy. To place the interlocking in automatic operation, all emergency releases must be in their normal position, all traffic must be established in the normal direction, and certain signals must be cleared. Then the master lever may be operated to the automatic position. The master lever may be operated from automatic to manual control at any time, except that certain types of circuit failure will prevent the actual transfer of control. A key operated circuit controller is provided on the machine to allow transfer to manual control in the event of a stored route selection or circuit failure. It may be operated only by the signal maintainer.

Sealed emergency time release pushbuttons are provided for the release of switch and traffic locking circuits. The switch release pushbuttons are of the spring return type and enable an operator to move a switch with the detector track circuit deenergized. The traffic release pushbuttons are of the stick type and allow the traffic lever to reverse traffic direction when there is a track circuit failure.

Turn-back tracks are automatic.

Once a local train has been routed to the turn-back tracks on the upper lever, the operation of switches and signals on these tracks is entirely automatic, as it is at all turn-back locations on the system. These circuits operate on a first-in first-out basis. During rush hours a man is stationed here to supervise schedules. Two levers on the Erie control machine allow the supervisor to put each local turn-back track out of service independently so that he may hold one train while another goes ahead.

The timing of the departure of local trains from the upper level, and of through trains on the lower level is controlled by two automatic dispatcher units in the tower. These operate from encoded 35-mm film and cause a blue departure signal to light. Two 20-pen recorders are also provided in the tower to record train movements.

Time requirements made it necessary to put the system into service upon completion of construction, with little test operation. As might be expected in a system as new and complex as this one, some bugs developed. One of these was the operation of the train identification cancel unit on the express track by the passage of a train

on the local track. This problem was solved by installing a shield of sheet metal on the supporting columns between the express and local tracks. Similar considerations required the decision to have the motorman carry the coil from one end of the train to the other at the terminals. If coils had been used at both ends of a train, the coil on the rear end of a local train would be almost the same distance from the wayside identification coils on the express track as the express train coil. All the difficulties were soon eliminated and the system is now operating smoothly.

The system was installed under the jurisdiction of J. W. Boorse, superintendent of power,, Philadelphia Transportation Co., and H. V. Varani, director of architecture and engineering, City of Philadelphia. All signal and Identra equipment was supplied by Union Switch & Signal - Division of Westinghouse Air Brake Co.

NEW BOOKS AND PUBLICATIONS.

[385 (02]

Directory of Railway Officials and Year Book, 1960-1961. London : Tothill Press Ltd., 33, Tothill Street, Westminster, S.W.1. — One volume of 618 pages (8 1/2 × 5 1/2 inches), (Price : 60 s. net.)

The Directory of Railway Officials and Year Book, 1960-1961, reaches with the present volume its 66th year of publication.

The first edition was compiled from official sources in 1895. The present edition containing 618 pages of text includes the general index and the personal index to railway officials, a noteworthy feature of the volume.

Railway developments throughout the world, including the rapid extension of electric and Diesel traction and also the construction of new railways in less developed countries, have necessitated numerous changes with this edition than occurs normally from one year to the next.

The closure of branch and minor lines, as in Great Britain, Ireland and the U.S.A., has reduced the mileages in some countries with a long railway history.

The scope of the volume remains unchanged, but there are numerous additional entries, such as the United Kingdom Railway Advisory Service, the Federation of Private Railways in Western Germany and the Swiss Institute of Transport.

All other features have also been revised to date but have not needed drastic overhaul.

This edition should prove as valuable as its predecessors. It will be greatly appreciated by all those concerned with railway matters.

A. U.

[656 (06 (43)]

Vorträge und Berichte der 3. Verkehrswissenschaftlichen Tage der Hochschule für Verkehrswesen Dresden. *(Lectures and Reports of the Three « Science of Transport » Days held at the Dresden Higher Transport School)* 8-11 June 1959. — One volume (6 × 9 in.) of 462 pages, with numerous illustrations. 1959 Dresden, compiled and published by the « Rektorat der Hochschule für Verkehrswesen Dresden. »

In June 1959, the Dresden Higher Transport School held its third reunion devoted to a study of the science of transport.

The reports of this important event, in which more than a thousand delegates took part, have just been published.

Unlike the procedure followed at the previous reunions, during which various subjects in connection with all the aspects of railway science were dealt with, the present session was organised around a single general theme, the evolution in the structure of the goods traffic.

Nearly 40 reports were presented which examined this question from every angle : the social aspect, national and international general economics, commercial policy, coordination between the different methods of transport, rail, road, water; operating problems arising in the case of main and secondary lines, as well as in the marshalling yards, safety and signalling, automation, construction and specialization of rolling stock, methods of traction.

Only 25 of these reports have been published in full owing to lack of space, but

the others have been summed up in sufficient detail for the reader to be able to appreciate their fundamental points.

There is no doubt that this important report will have the close attention of all those who for no matter what reason are concerned with goods transport.

R. S.

[**385** (08 (42)]

London Transport in 1959. — One volume (5 1 2 · 8 1 4 in.) of 90 pages, with illustrations and many tables. 1960, London Transport, 55 Broadway, Westminster, London, S.W.L. (Price : 2/6d.)

London Transport ended the year 1959 with a small surplus : £ 30 000, taking into account all its operating expenses and its full contribution to the costs of the B.T.C.

This result is definitely better that that of the previous year. The latter in fact ended with a deficit of £ 4 200 000, 50 % of which it is true was due, from the estimates made, to the long strike which paralysed the road services of L.T. for seven weeks during 1958.

The improvement must be ascribed to the operating economies made and to the increased rates which came into force during 1959, in spite of a reduction in the traffic and the increased wage awards.

As far as the traffic was concerned, in fact, 1959 showed a further reduction of some 9.5 % compared with 1957 in the number of passengers carried, a reduction due on the one hand to the traffic lost as a result of the strike of 1958 and which L.T. thinks it will never recover; and on the other hand, to the increased fares and to irregularities in the services caused by traffic congestion, and finally the ever increasing numbers of the public who have their own cars.

The report then gives in detail the work carried out or started during 1959. From this point of view, this year has been a particularly fruitful one, both on the road and on the railway side.

Amongst the most important works, mention may be made of :

— the starting of the three year programme to replace trolleybuses by buses;

— the putting into service of the new type R.M. buses, designed by L.T. which have been undergoing tests over the last five years;

— the inauguration of the £ 9 000 000 programme for the extension of the electrification of the Metropolitan Line, a programme which includes important work on the line, as well as the construction of a large number of new coaches;

— the modernisation of the signalling and installations on the District line;

— orders placed for new rolling stock for the Piccadilly and Central Lines.

It must also be reported that it is proposed to extend the B.E.S.I. equipment tests to centralised control of buses.

After a chapter devoted to recruiting, training and the remuneration of the staff, as well as the social services, the report studies the future development of some very important problems.

The question of the Victoria Line is raised once again; although studies are continuing and two short experimental tunnels have been built, the authorisation of the Government has still not been obtained. The L.T. reaffirms once again its conviction of the usefulness, if not the necessity, for such a line to relieve the congested road traffic and improve the connections between the stations of various regions.

The problem of the road traffic itself and the experiments tried to relieve congestion in the centre of London (pink zone) are discussed at length.

A study on the shortage of labour in London and on the distribution on the centrifugal principle of the population in the London region ends this chapter.

The report is completed by detailed statistics concerning the working of the undertaking and its material and financial position.

R. S.

[385 (08 (492)]

N.V. Nederlandse Spoorwegen. Jaarverslag 1959 *(The Netherlands Railways. Annual Report for 1959).* A pamphlet (9 × 11 in.) of 63 pages, with maps and illustrations.

The Netherlands Railways' operating accounts for the year 1959 showed a profit of 9.9 million Dutch Fl. compared with 0.2 million for the previous year. This result was obtained by an increase in the receipts (of 4.6 million Dutch Fl.) on the one hand, and a reduction in expenditure (by 5.0 million Dutch Fl.) on the other.

The volume of passenger traffic remained the same as in 1958; the goods traffic on the other hand increased by 2.8 %, due in the main to the increase in international traffic.

Under the heading *General Considerations,* the report enumerates the measures studied, decided upon or put into practice with the object of improving communications and the modernisation of the installations and rolling stock. The effects on the undertaking of the activities of the C.E.E., C.E.C.A. and U.I.C. are also examined.

The number of staff decreased by 398; in spite of an increase in productivity, there was a slight shortage of labour. The reasons for shortcomings in recruiting staff are analysed.

Efforts to increase safety at work and to improve working conditions are being actively pursued.

The length of the system (3 229 km) remains unchanged, as well as the proportions of single and double track, electrified and non-electrified lines.

A new type of sleeper for the running lines was introduced.

Several bridges are being built which will enable a certain number of level crossings to be suppressed; efforts made to increase safety at level crossings have been pursued : 16 automatic semi-barriers; lighting and signalling of level crossings.

The length of lines equipped with the automatic block with colour light signals had reached 751 km by the end of the year.

Modernisation work has begun at several stations and two new traction substations were built.

The number of electric and Diesel-electric locomotives has not changed; as far as the passenger rolling stock is concerned, there has been a reduction of some 1 364 seats; in the case of the goods traffic, a new type of wagon for carrying motorcars has been introduced: the average age of the wagons has been appreciably reduced.

Studies and research work are being carried out within the framework of the activities of the O.R.E. and A.I.C.C.F.

All these improvements and certain other reorganisation measures have made it possible to make improvements in the passenger and goods train services, which are listed in the report, and also to reduce appreciably delays due to bad weather.

Statistical tables, given as an appendix, show the activities of the railway during the year in question and its position at the end of the year.

H.-A. V.

[656 .281]

KERESZTY (P) (MAV-Workshops of Dunakeszi). **Twisting capacity of railway carriage structures (Practical investigation of derailments).** — Published in French in « Acta Technica Academiae Scientiarum Hungaricae », 1959-1960, Vol. XXVI, fasc. 3-4; Vol. XXVII, fasc. 3-4; Vol. XXIX, fasc. 1-2. — One volume (6 × 9 1/2 in.) of 126 pages copiously illustrated. — Budapest, Acta Technica, Postapiok, 440.

Railway vehicles must have a certain ability to adapt themselves to the unavoidable irregularities of the track, in order to run safely over high or low spots in the rails. This adaptedness is identical to the twisting capacity of the vehicle's

structure and closely connected to the safety against derailment; so it is necessary to determine it every time when checking the strength of the structural components.

In January 1953, the author has published in this same *Bulletin* a paper about the twisting capacity from the point of view of derailment investigations for two-axled vehicles. Nowadays the four-axle type begins to prevail amongst modern railway vehicles and therefore it became necessary to investigate the twisting capacity of these new carriages and wagons.

While in the case of two-axled carriages the simple value of the track fault determines the twisting of the carriage structure and the degree of danger of derailment, in the case of four- and more-axled carriages the peculiar data of the carriage itself are to be taken in account as well; the whole of these data are considered as the « converted » deviation of the track plane.

In the first and the second part of this paper, the method of computing the twist of conventional structures is elaborated. Here specialists can find ready formulae for checking the twist in existing vehicles as well as a method for computing the twist in new vehicle structures. After remembering the theory of two-axled vehicles, the author determines first the torsional capacity of two- and three-axled bogie trucks, and finally that of the whole system formed by the carriage body and its two bogie trucks.

The unloading of a wheel is intimately related to the deviation of the rails from their normal plane, which reduces the running safety of the vehicle on the track. Thus the vertical irregularities of the track and the torsional capacity of the vehicle determine together the safety against derailment. When dealing with these questions, the influence of the play between the lateral sliding surfaces on the twisting capacity is also elucidated.

In the last part, the author examines exhaustively the numerical analysis of three typical manners of derailment which occurred in traffic, and proves that carriage designers must not forget to take into consideration the twisting abilities of vehicles when checking their new constructions. Six examples have been elaborated with the help of the formulae worked out in the preceding parts : a four-axled carriage, a box wagon on bogie trucks, a high-sided wagon, a tank wagon, a six-axled flat wagon and a five-axled motor carriage being part of a multiple-unit Diesel train. These examples are treated with all required details, the characteristical faults of the several types of vehicles are shown and possible improvements are explained.

As a conclusion the author declares that the derailment of multi-axled vehicles is usually caused by more than one factor. Up to this day, and namely in his earlier study about derailments, these factors have been mentioned only qualitatively as their effects could not yet be valued out quantitatively because of the lack of sufficient experimental data in the technical literature. With this publication he hopes to fill the gap to a certain extent.

A. J.

MONTHLY BIBLIOGRAPHY OF RAILWAYS[1]

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British Railways 25-kV A.C. **electric locomotive.** (2 300 words & fig.)

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Cars specially designed for carrying heavy freight. (300 words & figs.)

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AKIRA HOSHI. — **Train air-conditioning.** (2 200 words, tables & figs.)

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MYERS (E.T.). — **Containerization :** what it is; what it means. (6 000 words & figs.)

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Containers take hold in Europe. (2 000 words & figs.)

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British Railways electrification. (2 800 words & figs.)

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Modern Transport, October 1, p. 7.
Points from the papers. **Locomotives, Rolling stock and equipment.** (1 800 words & tables.)

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English Electric locomotives for British Railways. (800 words & figs.)

1960 **625** .4 (42)
Modern Transport, October 8, p. 17.
Travolators at the Bank station. (1 800 words & figs.)

1960 **656** .28 (42)
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Accidents on British Railways. (1 500 words & figs.)

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Travolator installation at Bank station. (2 400 words & figs.)

1960 **656** .28 (42)
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Accidents on British Railways in 1959. (1 800 words, tables & figs.)

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British Railways A.C. multiple-unit stock. (1 700 words & figs.)

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Pressure-lubricated axleboxes. (1 600 words & figs.)

1960 **656** .212 (42)
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Hither Green continental perishable traffic depot. (2 800 words & figs.)

1960 **624** .5 (42)
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All-welded bridge at Dan-y-Graig, Western Region. (1 100 words & figs.)

1960 **656** .25 (42)
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Programme machines for L.T.E. District Line. (1 600 words & figs.)

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Electric repair and inspection depot at Ashford. (1 400 words & figs.)

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Electrification in the London Midland Region. (4 000 words & figs.)

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Electrification in the Eastern Region. (5 000 words & figs.)

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Diesel Railway Traction, October, p. 373.
Large gas-generator locomotives. (3 400 words & figs.)

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Diesel Railway Traction, October, p. 381.
More railcars for British Railways. (1 900 words & figs.)

1960 **621** .431 .72 (485)
Diesel Railway Traction, October, p. 389.
Diesel traction costs in Scandinavia. (1 200 words, tables & figs.)

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MESSERSCHMIDT (W.). — **Diesel units on rack railways.** (1 100 words & figs.)

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Diesel Railway Traction, October, p. 393.
Traction development in France-II. (4 000 words & figs.)

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Stratford locomotive maintenance depot. (1 500 words & figs.)

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Hydraulic drive facing U.S. tests. (1 900 words & figs.)

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JOHNSEN (A.M.) and DORNER (F.R.). — **Increasing service life of wheels.** (2 600 words & figs.)

1960 **625** .212 (73)
Railway Locomotives and Cars, September, p. 66.
EMD develops new wheel-slip control - 2. (900 words & figs.)

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Tubular body reduces hopper weight. (700 words & figs.)

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MENDIZABAL (D.). — **Aplicaciones y resultados experimentales de juntas alternadas** en carriles con distancias reducidas. (2 200 palabras.)

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GALAN GUERRERO (A.). — Algo sobre **racionalisazión del trabajo en los talleres de material y tracción** de la R.E.N.F.E. (2 500 palabras.)

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PEREZ PRIETO (C.). — **Aplicaciones de los plásticos en la construcción de material ferroviario.** (3 500 palabras & fig.)

In Italian.

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1960 **62** (01
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BRAY (A.). — Il rilassamento degli **estensimetri elettrici a resistenza.** (3 000 parole & fig.)

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1960 **621** .3
Ingegneria Ferroviaria, settembre, p. 693.
NOTARI (M.). — **Automazione, telecomandi ed elaborazione elettronica dei dati.** (6 000 parole & fig.)

1960 **621** .31
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PIRRI (D.). — Gli **effetti delle sovratensioni atmosferiche sugli impianti elettrici.** (6 000 parole & fig.)

1960 **625** .2
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BOSMAN (F.). — **Comportamento dinamico di una carrozza pendolare.** (5 000 parole & fig.)

1960 **621** .33 (45)
Ingegneria Ferroviaria, settembre, p. 722.
SIVORI (V.). — L'**elettrificazione** della linea Gallarate-Laveno-Luino. (3 000 parole & fig.)

1960 **385** .57 (45)
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BOGANELLI (E.) e DI CURZIO (U.). — **Profilo professionale dell'impiegato di banco** nei « Terminal » di città. (3 000 parole & fig.)

1960 **621** .338 (45)
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Gli **elettrotreni serie E.T.R. 250** (251 — 254) per corrente continua a 3 000 V. (800 parole & fig.)

Politica dei Trasporti. (Roma.)

1960 **656** .23 (4)
Politica dei Trasporti, ottobre, p. 479.
SANTORO (F.). — **Criteri di formazione dei prezzi e regolamentazione del M.E.C.** (*Continua.*) (3 600 parole.)

1960 **662**
Politica dei Trasporti, ottobre, p. 495.
SAVOJA (A.). — **I costi ed i consumi di energia per i trasporti ferroviari.** (2 500 parole.)

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1960 **691**
Rivista di Ingegneria, ottobre, p. 1105.
DUTRON (R.). — **Proposta di un metodo internazionale di prova per i cimenti.** Metodo Rilem-Cembureau per la determinazione delle resistenze meccaniche. (3 000 parole & tavole.)

1960 **691**
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FERRARI (S.). — Interpretazione teorica dell'**azione degli inibitori organici della corrosione.** (3 000 parole & fig.)

1960 **624** .2
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MATTIAZZO (F.). — **Calcolo teorico delle tensioni nelle travi a « T »** (con estensione al calcolo degli impalcati da ponte in cemento armato). (4 500 parole & fig.)

In Netherlands.

De Ingenieur. (Den Haag.)

1960 **669** .1
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VAN DER PAS (Th.J.M.). — Enkele aspecten bij de **verwerking van roestvrij staal.** (3 000 woorden & fig.)

1960 **621** .31
De Ingenieur, nr 45, 4 november, p. E. 133.
Enkele beschouwingen over de fabricage van moderne transformatoren.
VAN DIJK (G.M.). — I. Ontwikkeling in de constructie van transformatoren. (1 600 woorden.)
DE KUIJPER (C.E.M.). — De isolatie ten opzichte van aarde van gelijkmatig en getrapt geïsoleerde transformatorwikkelingen. (2 000 woorden & fig.)

Spoor- en Tramwegen. (Den Haag.)

1960 **656** (494)
Spoor- en Tramwegen, nr 21, 20 oktober, p. 359.
HOOFTMAN (J.C.). — **Verkeersproblemen rond de Sint-Gotthard-pas.** (2 000 woorden & fig.)

1960 **656**
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Vrijheid en vervoerbestel. (800 woorden.)

1960 **385** (09 .3 (45)
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HUPKES (G.). — De **spoorwegen in Italië** van 1839 tot 1905. (8 000 woorden & fig.)

1960 **385** .57 (492)
Spoor- en Tramwegen, nr 21, 20 oktober, p. 367; nr 22, 3 november, p. 382.
LANDSKROON (F.P.A.). — De **opleiding van het spoorwegpersoneel** in Nederland voorheen en thans. II-III. (4 500 woorden.)

1960 **656** .222 .6
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Een Duitse visie op de « **TEEM** »-**snelgoederentreinen.** (600 woorden.)

1960 **385** .517 (492)
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DE PREE (J.A.). — **Het maatschappelijk werk van de stichting voor Socialen Bijstand aan spoorwegpersoneel.** (2 200 woorden & fig.)

1960 **625** .144 .4
Spoor- en Tramwegen, nr 23, 17 november, p. 394.
HAUER (J.M.). — Voortgezette **mechanisatie van het wegonderhoud.** II. (1 000 woorden & fig.)

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Enkele aspecten van de « Formation Simultanée ». (2 000 woorden.)

In Russian (= 491 .7).

Avtomatika, Télémekhanika i Svias. (Moscou.)

1959 **656** .251 = 491 .7
Avtomatika, Télémekhanika i Svias, juin, p. 4.
FEDOTYEV (P.W.). — **L'application des signaux lumineux dans les gares.** (900 mots & fig.)

1959 **625** .151 = 491 .7
Avtomatika, Télémekhanika i Svias, juin, p. 6.
KARGALOV (N.I.). — Le schéma d'un **moteur d'aiguille à courant alternatif.** (1 000 mots & fig.)

1959 **656** .257 = 491 .7
Avtomatika, Télémekhanika i Svias, juin, p. 13.
ROSENTAL (A.M.) et KAGAN (I.I.). — **Sur les exigences concernant les installations du tableau de commande et de contrôle optique.** (1 700 mots & fig.)

1959 **656** .259 = 491 .7
Avtomatika, Télémekhanika i Svias, juin, p. 19.
TALYKOV (A.A.). — Les **circuits de voie à courants codés de gares.** (1 900 mots & fig.)

1959 **656** .254 = 491 .7
Avtomatika, Télémekhanika i Svias, juin, p. 45.
AFANASYEVA (S.I.) et LIBMAN (M.R.). — Le problème de l'adaptation du temps d'avertissement dans les dispositifs de **signalisation automatique de passages à niveau.** (2 000 mots & fig.)

1959 **656** .257 = 491 .7
Avtomatika, Télémekhanika i Svias, juillet, p. 4.
REPINE (A.V.). — Quelques problèmes concernant les **projets d'installations de commande centralisée.** (2 200 mots & fig.)

1959 **656** .254 = 491 .7
Avtomatika, Télémekhanika i Svias, juillet, p. 8.
KASIMOV (A.A.) et FILIPPOV (S.P.). — Les **dispositifs pour réponse à la voix.** (1 500 mots & fig.)

1959 **656** .257 = 491 .7
Avtomatika, Télémekhanika i Svias, juillet, p. 11.
KOUTYINE (I.M.). — **Quel appareil de commande centralisée choisir** ? (1 400 mots & fig.)

1959 **621** .332 = 491 .7
Avtomatika, Télémekhanika i Svias, juillet, p. 14.
SNARSSKY (A.A.). — Les **câbles pour grandes lignes ferroviaires électrifiées en courant alternatif.** (2 400 mots, tableaux & fig.)

1959 **625** .42 (47) = 491 .7
Avtomatika, Télémekhanika i Svias, juillet, p. 29.
SKOROBOGATOV (A.M.). — L'**augmentation du débit des lignes du Métropolitain** de Moscou. (1 800 mots & fig.)

1959 **656** .254 = 491 .7
Avtomatika, Télémekhanika i Svias, août, p. 9.
FELDMAN (A.B.). — **Appareil à mesurer les tensions perturbatrices.** (1 900 mots & fig.)

1959 **656** .253 = 491 .7
Avtomatika, Télémekhanika i Svias, août, p. 13.
BYELOV (K.P.). — Les **sources atomiques de lumière et leur application dans la signalisation lumineuse.** (1 100 mots & fig.)

1959 **656** .259 = 491 .7
Avtomatika, Télémekhanika i Svias, septembre, p. 11.
BOULKINE (N.A.). — Les **processus électrochimiques dans le shuntage sur les circuits de voie** et le problème de l'élévation de leur sensibilité par des impulsions à courant continu à tension élevée. (3 400 mots & fig.)

1959 **656** .254 = 491 .7
Avtomatika, Télémekhanika i Svias, septembre, p. 18.
KRIVITZKY (K.A.) et PADERNO (I.P.). — Les **télécommunications par haut-parleurs dans les parcs de wagons.** (1 600 mots & fig.)

1959 **656** .254 (47) = 491 .7
Avtomatika, Télémekhanika i Svias, septembre, p. 21.
FELDMAN (A.B.). — **Principes fondamentaux des télécommunications téléphoniques à haute fréquence** dans les réseaux de câbles à grande distance du Ministère des Communications en U.R.S.S. (2 300 mots & fig.)

Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta. (Moscou.)

1959 **656** = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 3.
MALAKHOV (K.N.). — Tendances principales dans le progrès technique de la **mécanisation des chargements et des déchargements.** (1 300 mots.)

1959 **625** .2 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 6.
BILIK (Ch.M.). — **Les matières plastiques employées comme éléments de friction du matériel roulant.** (2 200 mots & fig.)

1959 **625** .214 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 11.
CHADIKYANE (V.S.), KORE (I.D.), KOGAN (M.S.) et TSOURKANE (I.G.). — La résistance due aux lubrifiants consistants sur la rotation des **roulements d'essieux à rouleaux.** (1 600 mots & fig.)

1959 **625** .212 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 16.
NAOUMOV (I.V.) et GOUDKOV (V.N.). — **Méthodes pour abaisser le poids des roues des wagons.** (1 800 mots & fig.)

1959 **621** .431 .72 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 22.
PIVOVAROV (L.A.). — **Construction rationnelle de l'aspirateur dans les autorails Diesel.** (1 100 mots & fig.)

1959 **621** .13 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 25.
BARKHATNY (V.D.). — Sur l'appréciation des **méthodes d'enseignement ayant trait aux locomotives.** (1 500 mots & fig.)

1959 **625** .113 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 32.
VICHNYAKOV (A.I.). — **Recherches sur la courbure et sur la forme des courbes projetées dans la reconstruction des voies de chemins de fer.** (1 100 mots & fig.)

1959 **625** .141 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 35.
POPOV (S.N.). — Méthode nouvelle pour déterminer la solidité du **ballast.** (2 200 mots & fig.)

1959 **656** .223 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 40.
BARKOV (N.N.) et TIKHONTCHOUK (Y.N.). — Sur l'efficacité de l'obtention du **chargement maximum des wagons.** (1 600 mots.)

1959 **656** .223 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 43.
PETROVA (S.V.). — Sur la nécessité de créer un **nouvel index de chargement de wagons** et sur l'amélioration de la méthode de l'appréciation de l'intérêt économique de son accroissement. (1 900 mots.)

1959 **656** .223 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 6, p. 46.
GORDON (M.D.). — Sur l'**indice d'utilisation du chargement des wagons** dans le but de les répartir rationnellement sous la charge. (1 600 mots & tableaux.)

1959 **625** .173 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 3.
KARPOV (N.A.). — Nouveaux mécanismes et appareils utilisés dans l'**entretien courant de la voie.** (2 300 mots & fig.)

1959 **621** .332 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 9.
OVLASSIOUK (V.Y.) et SOUKHOPROUDSKY (N.D.). — **Commande à distance des disjoncteurs** du réseau des lignes de contact sur les lignes électrifiées en courant alternatif. (2 000 mots & fig.)

1959 **621** .333 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 13.
MANTZEV (V.D.) et TCHOUVERINE (Y.I.). — **La protection des moteurs des locomotives électriques pendant le freinage par récupération.** (2 600 mots & fig.)

1959 **621** .332 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 17.
MOTCHENOV (I.G.). — Les caractéristiques extérieures les meilleures d'un **mutateur.** (1 800 mots & fig.)

1959 **625** .241 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 21.
ASSTAKHOV (P.N.). — Sur la **résistance des wagons-tombereaux.** (1 700 mots & fig.)

1959 **656** .221 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 24.
STROMSSKY (P.P.). — L'**influence du vent sur la résistance d'un train.** (2 100 mots & fig.)

1959 **625** .142 .2 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 28.
JOUYKOV (A.S.). — Les **traverses en bois collé.** (2 200 mots & fig.)

1959 **624** = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 32.
ARTAMONOV (W.S.). — **Dégâts causés par la corrosion aux ponts en béton armé** et mesures de protection. (1 900 mots & fig.)

1959 **656** .222 .4 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 38.
WOROBYEV (N.A.). — **Influence du développement des voies et des emplacements des gares intermédiaires sur le débit des lignes ferroviaires à double voie.** (2 200 mots & fig.)

1959 **656** .222 .4 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 43.
IVANOV (L.N.). — Les méthodes de l'**analyse graphique des courants de trafic.** (2 300 mots & fig.)

1959 **625** .245 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 53.
TEREKHOV (A.A.), BAKANOV (W.I.), LOSINSKY (W.N.) et OJUGOV (Y.S.). — **Nouveau wagon-automoteur à décharge automatique.** (2 000 mots & fig.)

1959 **625** .248 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 7, p. 56.
DROUGALL (S.A.). — **Vibrateur pour le nettoyage des wagons-tombereaux.** (1 900 mots & fig.)

1959 **656** .254 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 3.
PENKINE (N.F.). — **Les nouveaux systèmes à fréquences pour la commande centralisée faite par le dispatcher.** (2 700 mots & fig.)

1959 **656** .254 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 9.
BRILEYEV (A.M.), OUSTINSKY (A.A.), POUGUINE (D.K.) et KHOUDOV (V.N.). — Le système du **réglage automatique du mouvement des trains** dans les sections de chemins de fer avec utilisation des canaux de radio. (2 400 mots & fig.)

1959 **621** .335 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 15.
REBRIK (B.N.) et GLOUCHKOV (E.F.). — Les **nouvelles locomotives électriques N 60 à courant alternatif.** (2 300 mots & fig.)

1959 **621** .335 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 21.
GRIGORYEV (E.T.), KRAVTCHENKO (A.I.) et NESTEROV (S.D.). — Les **accouplements transversaux élastiques entre les bogies des locomotives électriques.** (1 700 mots & fig.)

1959 **625** .282 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 29.
ISVOLENSKY (L.W.), NEMOUKHINE (V.P.) et KOSYRYEV (Y.M.). — **La locomotive Diesel-électrique pour voie étroite.** (2 000 mots & fig.)

1959 **625** .216 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 33.
INCHAKOV (N.N.), GOLOVANOV (W.G.), KLEMENTOV (V.I.) et KOMOLOVA (E.F.). — **L'attelage automatique** en acier à faible teneur, mais à résistance élevée. (2 200 mots & fig.)

1959 **625** .251 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 37.
FOKINE (M.D.). — **Appréciation du rendement des freins et calcul des distances de freinage.** (1 300 mots & fig.)

1959 **625** .14 (01 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 40.
BOTCHENKOV (M.S.). — **Détermination des contraintes et des déplacements des rails soudés pendant la période du dégel du ballast.** (1 200 mots & fig.)

1959 **625** .2 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 51.
IVANOV (N.W.). — L'augmentation de la stabilité contre l'**usure des pièces en fonte du matériel roulant.** (1 200 mots & fig.)

1959 **625** .2 = 491 .7
Viestnik Vsesoyousnowo Nautchno-Issledowatelskowo Institouta Jelezno-Doroznowo Transporta, n° 8, p. 53.
SEMISAGENOVA (A.A.). — Application de la méthode des analogies électromécaniques dans l'étude des **vibrations verticales du matériel roulant.** (1 300 mots & fig.)

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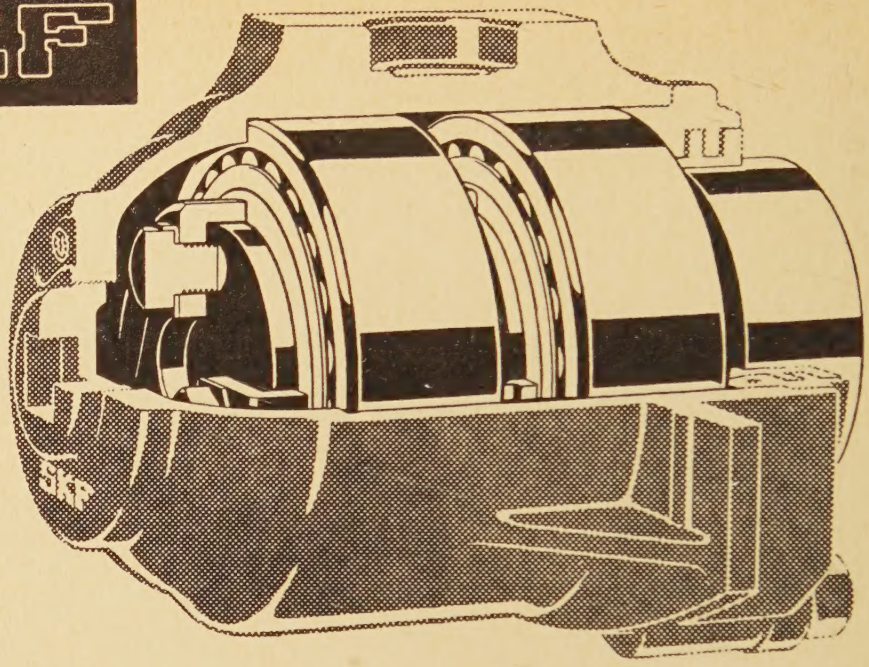

THE ULTIMATE AIM IS 100% ROLLER BEARINGS

At a meeting of Nordiska Järnvägsmannasällskapet (The Scandinavian Railwaymen's Association) in Oslo on 5th—6th May, 1959, a lecture was given entitled "Solid or built-up wheels". The following quotation from this lecture was published in the November 1959 issue of the Nordisk Järnbanetidskrift (Scandinavian Railway Journal) :

"Defects which have caused us most trouble in Sweden are hot running with plain bearings, cracked wheel seats, loose tyres, and flats on the tyres. Measures taken during the 1950s resulted in the number of cases of hot running being reduced considerably, from 9.3 goods wagons per million wagon-axle miles in 1951 to 0.6 in 1958. This favourable development was largely brought about by substantial investments in conversions from plain bearings to roller bearings. The ultimate aim is 100% roller bearings.

It was hardly necessary to calculate whether or not this would be economic, since this was self-evident in the light of the following advantages which weigh heavily in favour of roller bearings :

1) The costs arising out of normal hot running and of severe hot running resulting in broken journals and derailments are reduced.
2) Periodic lubrication of bearings between overhauls is no longer necessary.
3) The interval between overhauls of goods wagons has been increased from 3 to 4 years.
4) Wheels fitted with roller bearings have less frictional resistance."

SOCIETE BELGE DES ROULEMENTS A BILLES SKF S. A.

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